CHAPTER 7 POWER SUPPLY

7.1 Introduction

The tsunami of the 26th December, 2004 caused severe damage to the electrical infrastructure of the country. It completely disrupted the power supply in at least 95 islands, which is about 48% of all islands with electricity. However, by 6th January, 2006, almost 98% of inhabited islands have their electricity supply temporarily recovered and restored.

In almost all the affected islands, the damage occurred to the underground distribution network rather than generation facilities. Seawater deteriorated underground cables and cable joints in terms of insulation. Although there is no official record, it is reported that more power interruptions are caused by the damage to the distribution system.

On the other hand, most generators are operating in satisfactory conditions. Table 7.1 shows the generators that have been procured and installed in Laamu Atoll by International Red Cross.

Table 7.1 Generators Procured by International Red Cross in Laamu Atoll

Island	Capacity	Delivery date
Isdhoo	60kVA	2005/1/22
Isdhoo-Kalaidhoo	60kVA	2005/1/22
Maabaidhoo	60kVA	2005/1/22
Hithadhoo	80kVA	2005/2/27
Dhanbidhoo	80kVA	2005/2/27
Gan-Mukurimagu	150kVA	2005/2/27
Fonadhoo	80kVA	2005/2/27

The project aims to restore and rehabilitate the low voltage (400/230V) power distribution systems in five islands (Isdhoo, Isdhoo-Kalaidhoo, Maabaidhoo, Gan-Mukurimagu and Maavah) in Laamu Atoll, considering the extent of the tsunami damage and future sustainability of power supply by the island committees.

7.2 Present Conditions

The people who live in the tsunami affected areas are currently suffering from frequent power outages, because the temporary cables and distribution boxes are not appropriately designed in consideration of existing load current. Power supply has already recovered in many affected islands but only temporarily. Many cables are connected without jointing materials underground, distribution boxes are substituted by plastic buckets and pet bottles. These improper installation will result in frequent line fault and cause severe damage on the consumers equipment. Electricity is being supplied by the Island Development Committees (IDCs), which lacks proper engineering capabilities to assess and repair damaged power supply equipment.

As for generation facilities, it is noted that two or more generators cannot be operated at once in many islands, because there is no synchronous panel (even though we introduce synchronous panel, technicians from each Island Committee shall be trained well by on-the-job training).

7.3 Planning and Design Policies

It is said that most distribution systems are not in compliance with the regulation of Maldives Electricity Bureau (MEB), which is the regulating authority and policy maker for generation, distribution and utilization of electricity, including tariff setting in the whole country. The project shall be planned and designed to rehabilitate power system to the level which could satisfy technical standard established by the MEB.

At the same time, the distribution system should be restored within the shortest possible time, considering the needs of electricity as a lifeline in outer islands.

7.4 Cost Evaluation

The estimated cost of the power supply project at the design stage was as follows:

Table 7.2 Project Cost Estimation

	Item	BOQ Unit	Unit Price(US$)	Amount (US$
Equipment Cost	1. Low Voltage Cables			
	(1)Main Distribution Cables 4 core 120mm^2	900 m	55.17	49,653
	(2)Main Distribution Cables 4 core 70mm^2	500 m	23.75	11,875
	(3)Main Distribution Cables 4 core 50mm^2	2100 m	16.82	35,322
	(4)Main Distribution Cables 4 core 35mm^2	6400 m	15.12	96,768
	(5)Main Distribution Cables 4 core 25mm^2	11300 m	12.92	145,996
	(6)Branch Distribution Cables 4 core 16mm^2	1250 m	9.75	12,188
	(7)Branch Distribution Cables 2 core 6mm^2	79750 m	1.41	112,448
	2. Low voltage Distribution Box			
	(1)Feeder Pillars	7 units	2000	14,000
	(2) 18MCBs	48 units	500	24,000
	(3) 12MCBs	109 units	450	49,050
	3. Tools and Installation Materials	1 set	26400	26,400
Transportation	From Male to each island	1 set	45300	45,300
Installation works	Low voltage Distribution Box	1 set	90100	90,100
Total cost	Without Consulting Service Fee			713,099

Source; JICA Study Team

The tender price at the contract of the power supply projects were 62,742,197 Yen.

7.5 Construction and Implementation Plan

7.5.1 General

The supplier shall carry out the following works under the project.

(1) Supply of goods to the concerned island harbours in the project sites.
(2) Check of the goods after delivering them to the harbours.
(3) Delivery of the packing list of goods to the end user and obtain their signatures on it.
(4) Installation of all the distribution boxes in concrete frames.
(5) Supply of water pumps and of its fuel to remove water from cable trench before cable installation.
(6) Installation of all the glands to the distribution boxes.
(7) Installation of all the cables from the glands.
(8) Connection of all the cables to the terminals and MCBs.
(9) Labeling of all the cables.
(10) Labeling of all the DBs.
(11) Connection of all the consumer cables to the consumer meter boards.
(12) Commissioning of the distribution network.
(13) Test of the distribution network in the presence of the authorities concerned.
(14) Obtaining all the necessary approvals for the distribution network by JICS.
(15) Handover of the distribution network to the MoAD after approval by JICS.

The supplier shall be reminded that 55 houses in Isdhoo-Kalaidhoo are subject to relocation to proposed new residential plots as shown in Drawing E-07-01 of the tender specifications. Final location shall be informed by the end user before awarding the contract.

Work responsibilities of the supplier and the recipient (Island Committee) are shown in following Table 7.3.

Table 7. 3 Work Demarcation Between the Supplier and the End User

Work Item	Supplier	Island Committee (End-user)	Remarks
Procurement of LV Cables	○		
Procurement of Distribution Box	○		
Transportation of all equipment from Male' to the harbour	○		
Transportation of all equipment from the harbour to the site		○	
Proper storage and maintenance of equipment at the site		○	
Preparation of site to install LV cables and		○	

distribution boxes			
Installation of LV cables, including excavation and backfilling		○	
De-watering of LV cable trench (Removing water from cable trench before installation of cable)		○	
Supply of water pumps, supply pipes and their fuel for the above de-watering of LV cable trench	○		
Connection of LV cables to distribution box	○		
Pre-inspection of existing kWh meter boards and procurement of ELCBs, MCBs, earthings, kWh meters etc. in order to meet the MEB standard		○	Individual home (consumer) will be required to procure necessary equipment.
Installation of distribution box	○		
Installation of distribution box concrete frame		○*)	
Acceptance test	○	○	

Note: *) Necessary cement shall be procured and transported to each island by the supplier.

7.5.2 Supply of the Goods

The goods to be procured under the project shall be of its best quality and the reliability of the goods shall be maintained.

7.5.3 Factory Test and Inspection

The factory test and inspection of the goods to be procured under the project shall be carried out by the supplier at the manufacturers' factories and/or proper places to ensure that the goods complies with the provisions of the contract.

Test and inspection items shall consist of the following:

- Quantity inspection
- Visual inspection
- Dimensions of the equipment and materials

The quantity inspection and visual inspection shall comprise the check of quantities and quality of workmanship for the goods according to Schedule V Technical Specifications Sheet in Part V Forms of Tender in Tender Documents. The supplier shall provide all necessary test equipment, materials, special tools, consumable items, etc., for the factory test and inspection at his own cost.

The supplier shall submit all the reports of the factory test and inspection to JICS for approval with evidential photographs of the goods at the factory test and inspection.

7.5.4 Installation and Commissioning

The supplier shall install the distribution boxes and connect all the cables to the boxes in accordance with the instruction given by JICS. The scope of work includes the followings at least.

(1) Procurement and delivery of necessary cement for distribution box concrete frame to each island harbour.
(2) Installation of the distribution boxes in the concrete frame with screws, wall plugs, etc.
(3) Meggar test of all the cables. (Phase to phase, phase to earth, phase to neutral etc.)
(4) Installation of the PVC glands inside the boxes.
(5) Preparing the cable insulation to insert the cables to the glands.
(6) Insertion of all the cables to the glands.
(7) Arrangement of all the cables from the bottom of the box inside the concrete frame.
(8) Installation of cables ties to the cables.
(9) Installation of cable tags at the cables below the box inside the concrete frame.
(10) Arrangement of all the main cables inside the box.
(11) Cut of the cables to connect to the cable terminal.
(12) Installation of lug sleeves to the cables
(13) Installation of lugs to the cables.
(14) Connection of the main cables to the terminal block.
(15) Arrangement of all the branch cables inside the box.
(16) Installation of cable ties to the cables in bunches.
(17) Installation of the numbering sleeves to the cables.
(18) Connection of the live wires to the MCBs.
(19) Connection of the neutral wires to the neutral links.
(20) Connection of the earth wire to the earth links.
(21) Labeling of the box.
(22) Cleaning inside the box very well.
(23) Other necessary works to install the box.
(24) Commissioning the box.
(25) Test of the voltage from the main terminals.
(26) Connection of all the consumer cables to the concerned consumer.
(27) Energizing the consumer meter board.
(28) Check of the voltage from the consumer meter boards at full load.
(29) Other necessary works to install and commission the distribution boxes and the cables.

During the installation and commissioning works, the supplier shall bear the following costs.

(1) Air transportation cost from Male' to Kaddhoo
(2) Inland transportation in Laamu Atoll

(3) Ocean transportation in Laamu Atoll
(4) Ocean transportation from Male' to Laamu Atoll
(5) Land transportation in Male'
(6) Food and accommodation in Male' and in Laamu Atoll
(7) Laundry services in Male' and in Laamu Atoll
(8) Medical services in Laamu Atoll as well as in Male'
(9) All other types of similar costs arising out of the work

7.5.5 Drawings

The supplier shall submit two (2) sets of the following drawings to JICS for approval.

Table 7.4 Submission Schedule of Drawings

No.	Name of Drawings	Date of Submission
1	Single line diagram of the distribution box	No later than thirty (30) days after awarding the contract
2	Dimensional drawings of the distribution box	
3	Schematic diagram of the distribution box	
4	Equipment layout of the distribution box	
5	Detailed Equipment specifications and catalogues for ➢ All types of LV cables ➢ Distribution box ➢ Accessories ➢ Tools	
6	Factory test/inspection report	Within seven (7) days after the test/inspection
7	As-built drawings of the distribution box	At the completion of the installation work
8	As-built drawings of the whole network drawn on the scaled map	
9	Installation completion report	

"No.8 As- built drawings of the whole network drawn on the scaled map" shall include the name of residence, meter board location of the residence, consumer cable route of each residence and public facilities, main cable route indicating the cable sizes in meters, cross sectional drawings of the cable trench etc. The map shall be drawn from AutoCAD as archive file and all the services included in the map shall be drawn in separate layers.

"No.9 Installation completion report" shall have the following description and data.

- Statement that the goods have been supplied and site installation work and commissioning has been completed, with the evidence of approval of the Acceptance Test Report.
- Description of the supplier's activities up to the completion of the Project, including actual time schedule.

- Statement that all the documents, drawings and manuals have been supplied with all records of documentation and correspondence as evidence.
- Statement that clearing of the Project Sites has been completed with photographic evidence.
- Completion photographs showing the actual progress of the work.

As of December 2005, the above drawings from No.1 to No.5 have been submitted by the Contractor, and approved by JICS and/or its Consultant.

7.5.6 Acceptance Test

The Acceptance Test shall be carried out by the supplier at the completion of the installation work of the goods, in the presence of the all concerned parties including JICS.

The acceptance test shall consist of the following:
- Visual inspection
- Function and performance test

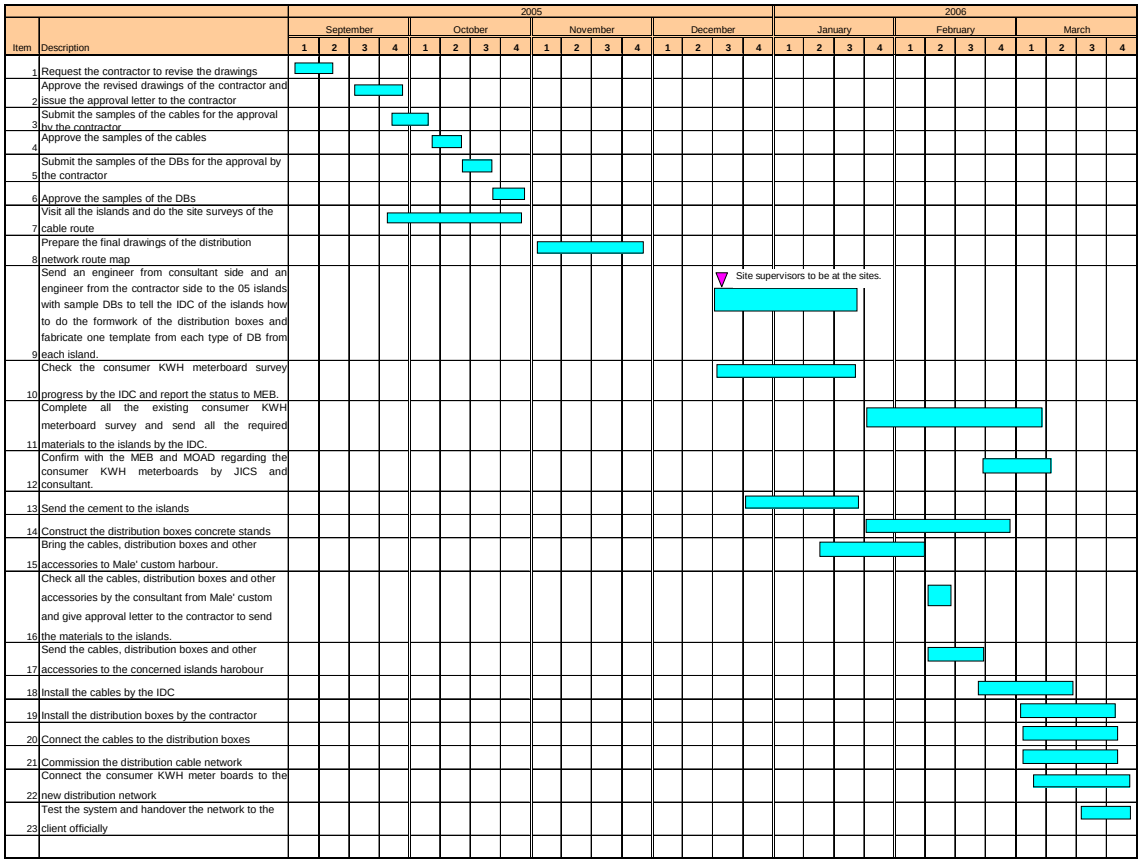
The visual inspection shall comprise a dimensional and system check, quantity check of the goods supplied under the contract and the check of workmanship according to the approved drawings.

The function and performance test shall comprise the functional check and confirmation of performance through the actual operation of the facilities in accordance with the provisions of the contract. The supplier shall provide, at his own expense, all staff, equipment and materials, tools including consumable items for the acceptance test.

7.5.7 Implementation Schedule

The implementation schedule of the Project is shown in the Table 7.5 as follows.

Table 7.5 Implementation Schedule of the Project for Power Distribution System in Laamu Atoll



7.6 Technical Specification of Equipment

7.6.1 Low Voltage (LV) Cables

(1) General Conditions

1) The supplier shall submit the results of type test certificates issued and approved by reputable, independent testing laboratories. Such tests would be on random samples at the discretion of the engineer and failure to meet the conditions of test could result in rejection of a complete batch of cables.

When such tests are called, they shall comprise the following:

- Partial discharge test
- Bending test, plus discharge test
- Dielectric power factor as function of voltage and capacitance measurement, and as a function of temperature
- Heating cycle test plus partial discharge test
- Voltage AC test
- Non-electrical tests as stated in IEC 60502.

2) Conductors

All conductors are manufactured to BS 6360 “Conductors in insulated cables and cords”.

3) Stranded copper

These shall have to be manufactured from plain annealed high conductivity copper.

4) Insulation

Conductors are insulated with PVC which is applied by extrusion to form a compact homogeneous layer. All PVC compounds used comply with BS 6746 “PVC insulation and sheath of electric cables”.

5) Fillers and beddings

The cable cores are laid up with fillers between the cores where necessary. Single core cables have extruded PVC beddings, whilst multicore cables have at least two layers of suitable tape to provide bedding for the armour.

6) Over sheath

All cables shall be provided with an extruded outer sheath of black PVC complying with the requirements of BS 6746.

Core identification: Cable cores are identified as shown below.

Twin core:	red, black
Four core:	red, yellow, blue, black

7) Embossing and marking

The over sheath of each cable shall be embossed as follows

- Cable manufacturer name
- Length of cable in meters
- Cross sectional area of the cable
- Manufactured date.
- Voltage grade.

8) Voltage testing

All cores shall be spark tested during manufacture, and each completed cable is subjected to an A.C. voltage test. Test voltages shall be in accordance with BS 6346.

(2) Conditions of the supplier

Before manufacturing the cables, the supplier shall send cables manufacturer’s details and cables

catalogues to JICS for approval. The details of the cables shall include all the characteristics of the similar tables given in the technical specifications.

Before shipping the cables, the supplier shall submit a piece of 1,000 mm length from each type of the cables, which is to be procured under the contract, to JICS's Liaison Office in Maldives for its approval. These sample cables shall be labeled with the following at least.

- CSA of the cable.
- Name of the manufacturer.
- Length of the cable.
- Name of the client embossed.
- Standard of the cables.
- Others if necessary.

(3) Conditions of the Cable Manufacturer

The cable manufacturer shall have achieved the BASEC (British Approval Service for Cables) certificate or license.

7.6.2 Distribution Boxes

(1) General

The distribution boxes shall be GRP (Glass Reinforced Polyester) enclosed distribution boxes. The boxes shall be designed to install the cables from the bottom entrance.

Before shipping the boxes, the supplier shall assemble one set of distribution box as a sample and send the sample to JICS's Liaison Office in Maldives for its approval. As JICS approves the sample, the supplier can start assembling all the other boxed in accordance with the sample.

The sample submitted to JICS will not be returned to the supplier. If the sample is not approved, the supplier shall also submit another sample to JICS until obtaining the approval.

Distribution boxes shall only be the high quality branded GRP enclosure including the following at least:

- GRP enclosure IP65.
- Polyester enclosure, sealed enclosure IP65 made of Glass Reinforced Polyester (GRP).
- IP rating according to IEC 60529.
- Insulation class II according to IEC 60232.
- Body made up of one piece up to height 800mm.
- Canopies on both top and bottom.
- Plain door equipped with two or three locks with 8 mm triangular centres.

- Door easily removable for drilling gasket directly moulded on the door.
- 04 fixing bolts in the back of the enclosure for mounting plate fastening.
- Color: RAL 7032.
- Mounting Plates.
- Back plates.
- Modular chassis with the front cover.
- Depth adjustment slides for enclosure.
- Three pole three step fork insulated busbars.
- Insulated neutral links
- Insulated earth links
- Flexible cables to do the internal wiring of the boxes.
- Four pole terminal blocks.

(2) Accessories

All the accessories shall be provided by the supplier after submitting the samples of the accessories mentioned in Schedule V Technical Specifications sheet in Part V Forms of Tender in the Tender Documents, such as:

- Lugs from each type
- Glands from each type
- Lug sleeves from each type.
- Numbering sleeves from each type.

7.7 Recommendations

Island Committees in the project sites shall be prepared for pre-inspection of existing kWh Meter Boards and procurement of ELCBs, MCBs, earthings, kWh meters etc. in order to meet MEB standard. Otherwise, those consumers who don't meet MEB regulations will not be connected to the grid.

CHAPTER 8 SEWERAGE SYSTEM

8.1 Introduction

Sanitation in most islands is affected partly by pour-flush latrines connected to sewerage system, or to much lesser extent by defaecating holes made within the household compound. The construction, operation and maintenance of septic tanks involves unhygienic works, thus the system often suffer from poor performance due to bad maintenance. In many islands, sewerage system is not well designed, often malfunction, and usually convey raw sewage directly into the near-shore environment.

This situation can be easily understood by comparing the situation of two islands. The photo below shows two islands; the one on the left is a normal inhabited island and one on the right is a resort island. The inhabited island does not have a well designed sewerage system, whereas the resort island has a well maintained one. The groundwater in the inhabited island is probably rich in nutrients due to the inadequate sewerage system, and as a result has enhanced seagrass growth, which is the dark patch seen along the shore of the inhabited island. On the other hand, seagrass growth is not seen in the resort island probably due to less nutrients in the groundwater. Seagrass is not harmful but is one visible indication of the groundwater situation.

Comparison of Two Islands With and Without Adequate Sewerage System

8.1.1 Tsunami Impact

The Tsunami of December 26th caused severe damages to the sewerage infrastructure of the country. It totally devastated the groundwater situation in at least 95 islands, which is about 48% of all the inhabited islands. According to the residents of Isdhoo Island, 2~3m high waves advanced to the east seashore, then broke as 5m high waves and rushed through the middle of

the island from east to west, which was then followed by a 2nd wave. Unfortunately there are no photos of Isdhoo Island, but one photo of Thaa Atoll shows vividly the devastating force of the Tsunami event.

Tsunami in Thaa Atoll

In almost all the affected islands, similar impacts were recorded to the groundwater and underground sewage facilities including home toilet. Tsunami brought up manholes of septic tanks and scattered sludge and faecal matter, which has penetrated into the ground and worsened the groundwater situation.

Latest sampling test in Isdhoo Island shows the deterioration of groundwater quality. Each test showed coliform concentration of over 100 / 100ml (Table 8.1).

Table 8.1 Results of Groundwater Quality Survey

Sample ID	Sampling Location	Date Sampled	Sampling Method	Type of Water	Result/100ml	
					Total Coliform	Faecal Coliform
AO	L.Isdhoo 1	2005.7.20		Well	>100	>100
AP	L.Isdhoo 2	2005.7.20		Well	>100	>100
AQ	L.Isdhoo 3	2005.7.20		Well	>100	>100

8.1.2 Groundwater Structure

The groundwater in the Maldives islands has an unique structure, so called Lens Water. The land consists of coral sand that accumulated on the porous coral rock, which extends to the edge of coral reef. The annual average rainfall in the islands is approximately 2,000mm. Around 30% of the rainwater penetrate into the ground and accumulate as groundwater. The weight of the fresh water compresses the seawater into the porous coral rock. The seawater is then pressed

downward and sideward. A survey conducted by MWSA in 3 islands shows the situation of groundwater, which is shown in Figure 8.1. The survey shows the importance of groundwater conservation.

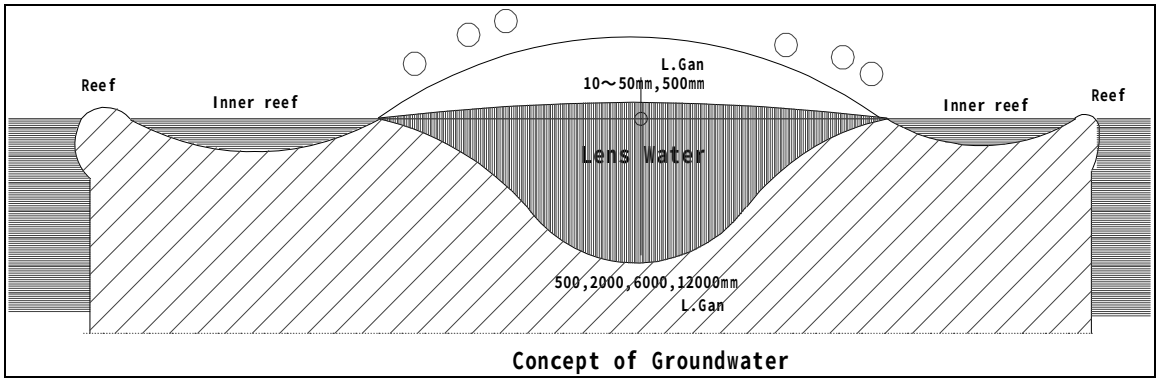


Figure 8.1 Schematic Diagram of Groundwater Structure in Maldives Island

8.2 Present Condition in Isdhoo Island

Aerial Photograph of Isdhoo Island

Like the other islands of Maldives, Isdhoo Island is low lying with ground levels generally less than 2m above sea level. In the Island there are two villages, Isdhoo area and Isdhoo-Kalaidhoo area. In the above photo, the one in the north of the island is Isdhoo-Kalaidhoo area, and the one in the south is Isdhoo area. Because Isdhoo-Kalaidhoo is surrounded by a wide reef flat, it is time consuming to reach to the fishing grounds of the open sea. Instead the areas have become farmers, thus Isdhoo-Kalaidhoo is an agricultural area. Due to the tsunami, their farmlands were severely affected.

After changing the focus island from Fonadhoo to Isdhoo Island at the end of May 2005, through the decision of GOM, the Study Team started the detail design study.

When the Study Team visited Isdhoo-Kalaidhoo village on May 25th with the basic design, the Study Team faced with relocation problems. 42 households wanted to move their house in the east coast to another area. But no plan is submitted yet. So, the Study Team had to finalize the basic design with a tentative relocation plan. On July 21st, the Team received the draft design of relocation plan from MPND. (Figure 8.2).

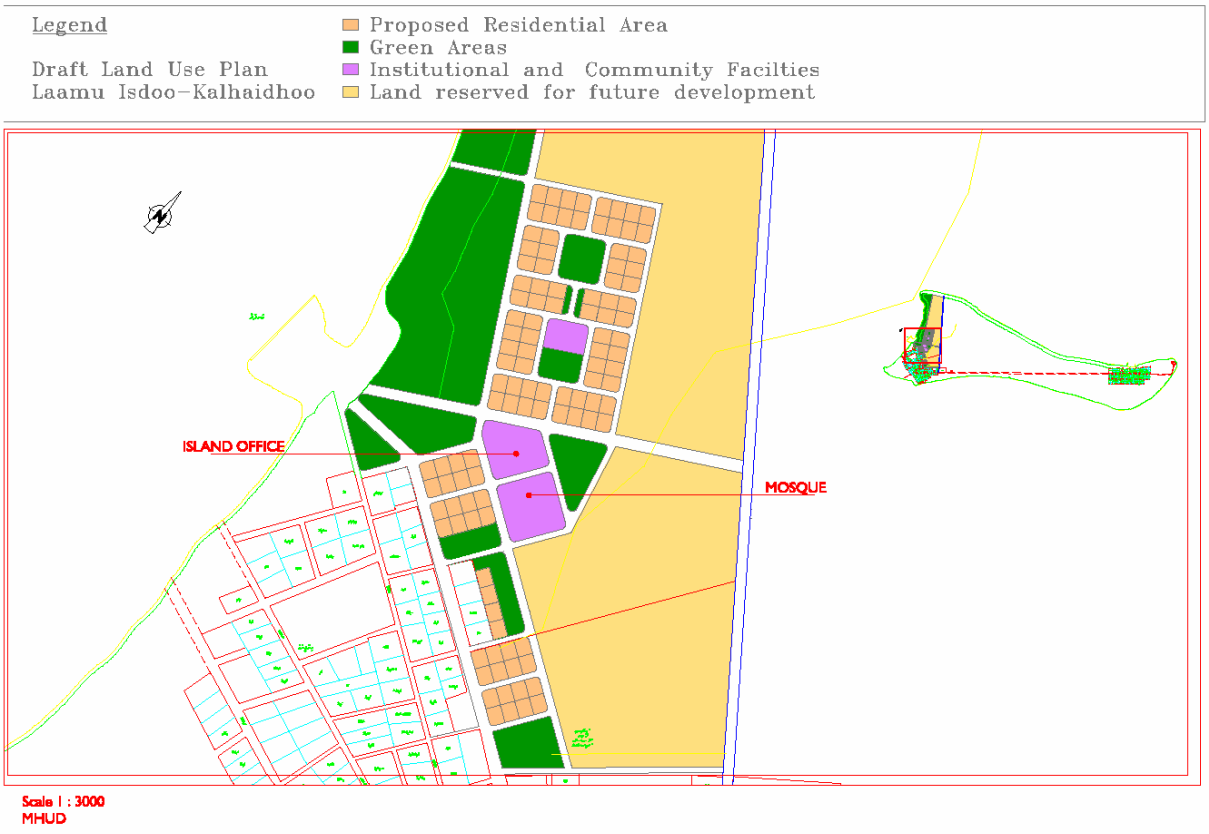


Figure 8.2 Relocation Plan of Ishdhoo/Kalaidhoo

On Sept.11th, MPND, MEEW and MOAD with the Study Team and British Red Cross (BRC) went to Isdhoo/Kalaidhoo to explain about the revised draft design of relocation plan to the householder. After this explanation the plan was finalized and according it, final sewerage design had been completed (Figure 8.2).

42 houses will be built by BRC for 42 evacuees but due to delay of road construction work by GOM, BRC has not yet started to build. Our project includes 42 Home Type Septic Tanks, pipe line network and treatment system such as Mounted Leach Field, 2nd Septic Tank those will be installed for these 42 houses. In case of delay, we should decide to change 42 home type septic tank installation works to equipment supply project. So further discussion will be needed among

the party concerned to the project, MEEW, MPND, MOAD and BRC.

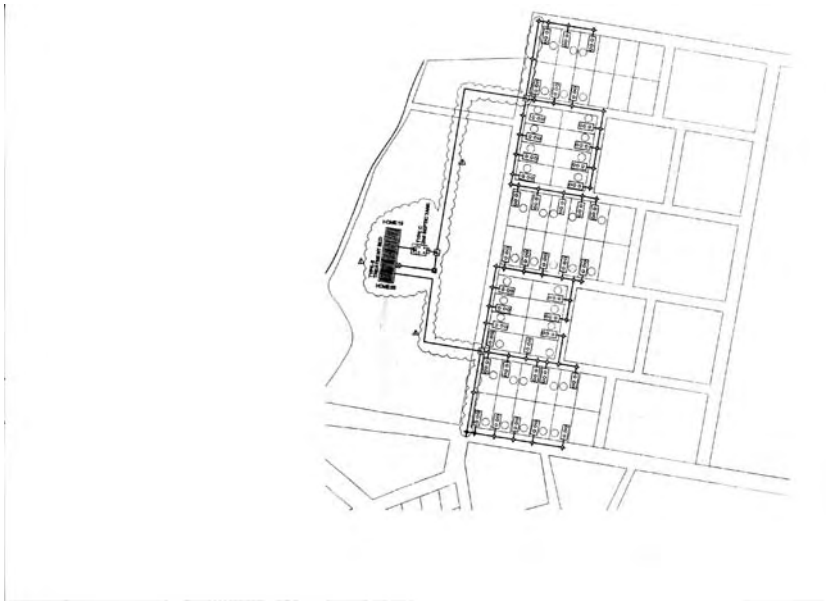


Figure 8.2' Lay-out Plan of the Sewerage System in Ishdhoo/Kalaidhoo

8.3 Planning and Design Policies

Most sewage systems in the islands are not in compliance with the minimum requirement of Maldives Water and Sanitation Authority (MWSA), which is the regulating authority and policy maker for water distribution and sanitation of the country. The project shall be planned and designed to the level satisfactory to the technical standard prepared by MWSA. At the same time, the sanitation system should be constructed within the shortest possible time.

(1) Preservation of the Groundwater

The aim of the study is to design a sewerage system that is capable of protecting the groundwater from further deterioration.

(2) Sustainability

The sewerage system must be designed as a sustainable system, having easy maintenance and low running cost. To assure its sustainability, a new operating organization will be established in the villages.

(3) Multi-step Differentiable Treatment System

To achieve high treatment performance of black water, the system combines 3 different treatment methods into one system, which is composed of up-flow type septic tank, 2nd septic tank with aeration chamber and dual soil treatment bed. For grey-water, slanted soil treatment system is employed. The systems are described below:

8.3.1 Outline of the Project

There are two areas for the project in Isdhoo Island. One is Isdhoo-Kalaidhoo area located in the southern part of the island, and the other is Isdhoo area located in the northern area. Between the two areas, in the centre of the island, there is a health centre with 6 beds. The construction office and workshop will be located in this area. The summary of the project is described in the following Table 8.2.

Table 8.2 Summary of the Project

	Site1: Isdhoo-Kalaidhoo Area	Site2: Isdhoo Area	Site3: Health Centre Area
Home type septic tank	130pcs	184pcs	
Communal type septic tank No.1	1pcs	1pcs	1pc
Communal type septic tank No.2	6pcs	7pcs	
Conveyance sewer piping	Covered above area	Covered above area	Covered above area
Intermediate pump station	14pcs	14pcs	1pc
2nd Septic tank with pump	7pcs	7pcs	1pc
Mounted Leach Field (Double Soil Treatment Bed)	7pcs	7pcs	1pc
Drying Bed	2pcs	2pcs	
Slanted soil treatment system	137pcs	190pcs	2pcs
Vacuum car	1pcs		

The Project is to be implemented on the basis of the following policies:

(1) MWSA is the responsible organization for the implementation of the project in Isdhoo Island.

(2) The project is defined not only as a project for improvement of the sewage treatment system, but as a project for contributing to the aqueous environment system as well as improving the groundwater conditions of the island.

(3) The objective of the project is to establish sewerage treatment system and improve ground water condition by means of replacing old septic-tanks and soak-pit system to new multi-step treatment system.

(4) The major components of the project consist of constructing the following facilities and thereby improving the situation of the sewage treatment system.

- Replacement of the existing deteriorated septic tanks to new one,
- Construction of sewerage conveyance piping network as a collecting system of sewage water,
- Construction of pump station to convey sewage water,
- Construction of 2nd septic tank as an aeration chamber
- Construction of Mounted Leach Field that compose of double treatment system for sewage water,
- Construction of drying bed for desludging system,
- Provision of maintenance and desludging system and equipment.

8.3.2 Multi-Step Treatment System

(1) Process of Multi-Step Treatment System

1st Step: **Home type septic tank**

Comprising of construction of the complete septic tank with two anaerobic chambers including the up-flow filter filling with aggregate. Three manholes are to be set onto two anaerobic chambers and up-flow chambers. Total volume of chambers is 1.5m^3.

2nd Step: **Mounted Leach Field** (Primary Treatment Bed)

Comprising of a concrete retaining wall filled with sand, charcoal and gravel filter for soil treatment bed that is separated into two parts by a wall. One part is primary treatment bed and the other is secondary treatment bed. These two treatment beds are comprised of dual soil treatment system. At first, about 60% of the collected effluent from septic tanks will be poured into the primary treatment bed through the pump station submersible pump. Through the soil bed, sewage water will be treated by aerobic bacteria and then flow out from the bottom of the bed to the 2nd septic tank.

3rd Step: **2nd septic tank with pump**

Comprising of a complete septic tank that has one aerobic chamber and pump pit with submersible pump that suck treated water from pump pit and convey water to the secondary mounted leach field for terminal treatment. In the 2nd septic tank, 40% of remaining collected sewage water and the treated water will be mixed, and in the aerobic chamber of the 2nd septic tank the mixed water will be treated again by aerobic bacteria. Using submersible pump of 2nd septic tank, treated water will be pumped up to the Secondary treatment bed for tertiary treatment.

4th Step: **Mounted Leach Field** (Secondary Treatment Bed)

Comprising of a concrete retaining wall filled with sand, charcoal and gravel filter for soil treatment bed that is separated into two parts by wall. This part consists the secondary treatment bed.

(2) Sewage Conveyance

Conveyance sewer piping – comprising of complete sewage water drainage system from septic tank through the intermediate pump station to the soil treatment bed or through 2nd septic to the Mount Leach Field.

Intermediate pump station – comprising of a complete pump pit with submersible pump that suck sewage water from pump pit and convey water from intermediate pump station up to the Mounted leach field or to 2nd septic tank through conveyance piping.

(3) Dry Bed and Desludging

Drying bed – comprising of in-let pit, drying bed and out-let pit. Drying bed is filled with coral sand and coral rock filtration, and in the bottom of bed there will be geo-textile filtration. This bed will be covered by transparent polycarbonate folded roof, which can be opened when collecting the soil for fertilizer.

Vacuum car – 2.0ton Truck Vehicle with 1,600l Vacuum Car.

1) 2.0ton Truck Vehicle with flat deck
   Length: 4,690mm, Width: 1,690mm, Engine: 2000cc
2) 1,600l Vacuum car with engine
   Name: Vacuum car, Type: DV-1600B or equivalent,
   Total Length: 3,000mm, Width: 1,390mm, Height: 1,645mm
   Tank length: 1,950mm, Width: 1,070, Height: 1,070
   Tank Volume: 1,600l, Weight: 500kg, Total Weight: 2,100kg
   Vacuum Pump: -0.067Mpa(50cmHg), 0.06Mpa(0.6kg/cm2)
   Pump Capacity: Sack 1,000l/min, Discharge 700l/min
   Engine: 2.9~4.4kw (4PS~6PS)
   Hose: Sacking hose 20m, Discharge hose 4m

(4) Grey-Water Treatment System

Slanted soil treatment system – comprising of three slanted plastic trays (1,000mm x 500mm), cover box and out-let pit under the box. This system is only for high-loaded grey water that flow out from kitchen basin and cloth washing basin. After treated water stay in the bottom out-let pit once, the water flow out into existing permeable pit as grey water.

8.3.3 Treatment Flow of the System

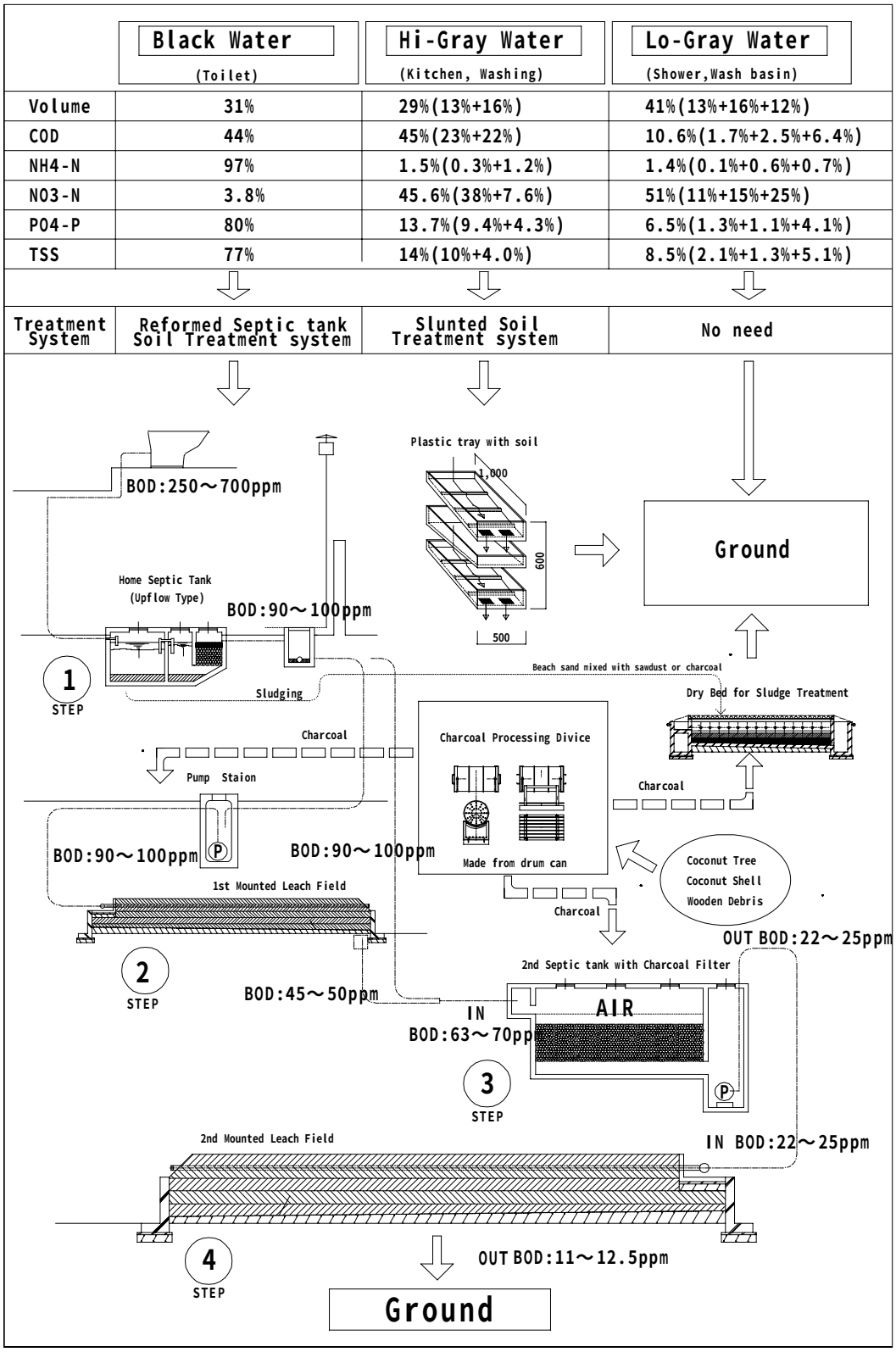


Figure 8.3 Schematic Diagram of the System

8.3.4 Improvement of the Items from 1st Report

(1) Home Type Septic Tank

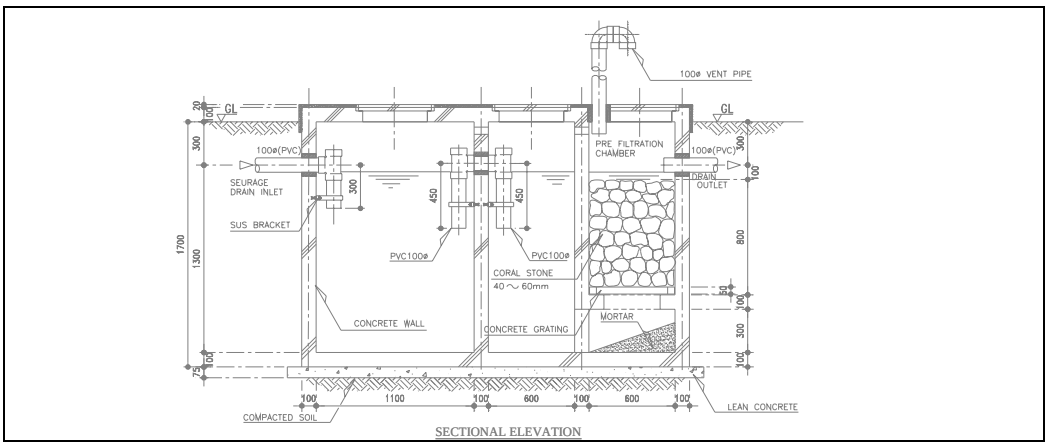


Figure 8.4 Design of Home Type Septic Tank

This type of septic tank was introduced by Dr. Duncan Mara of Dundee University in Scotland. In his publication “Sewage Treatment in Hot Climates”, Dr. Mara shows an example from India. The septic tank reduced 70% of the initial BOD and changed a malodorous, highly turbid, grey-to-yellow influent to an odorless, clear, light yellow effluent. In our experience in Cambodia, this up-flow type septic tank can reduce 64~85% of BOD and is very easy to maintain.

Proto-type FRP Septic Tank

To enforce durability of leakage, we studied to redesign home-type and communal type septic

tank by FRP (Fiber reinforced plastic). Above photograph shows one proto-type made by FRP in Sri Lanka work shop. According to inspection with MEEW, 2 design amendments will be done. One is change of manhole design from square-type to round-type, second is volume of 1st room. Totally 340 home-type septic tanks (138 for Isdhoo/Kalaidhoo and 202 for Isdhoo) will be produced in the factory. These FRP septic tanks will reduce the difficulty of installation work in the narrow space of household.

Proto-type FRP Junction Box

Also we tried to remake the Junction Box made by concrete to FRP because of reliability for leakage. In concrete made junction box, week-point is in the connection with Vinyl Pipe, but if we can use FRP junction box, connection with vinyl pipe is smooth and reliability of water proof ness is very high. Above photograph shows one proto-type made by FRP in Sri Lanka work shop. According to inspection with MEEW, smoothness of the bottom should be carefully secured.

654 FRP junction boxes produced in Sri Lankan factory will be reduced the difficulties of installation work because of high ground water level.

○ Increasing number of home-type septic tank

Number of Houses	Isdhoo/Kalaidhoo Area except Relocation Area	Isdhoo/Kalaidhoo Relocation Area	Isdhoo Area	Health Center Area	Total
Former	**88**	**42**	**184**	**0**	314
Additional	**8**	**0**	**18**	**0**	26
Total number	96	42	202	0	340

(2) Second Septic Tank with Aeration Chamber

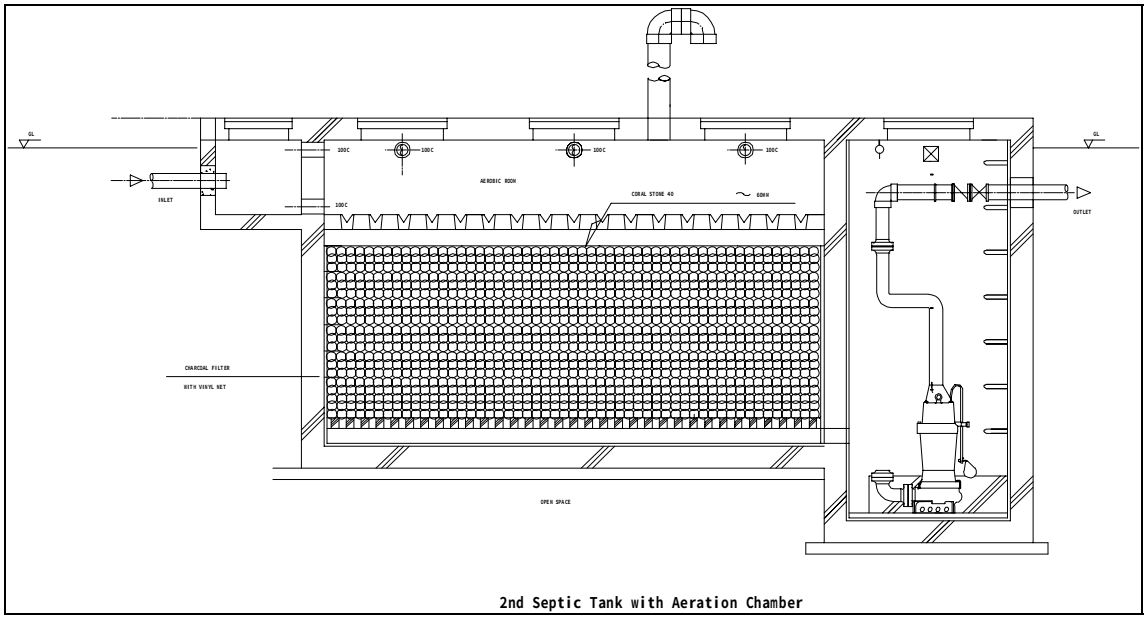


Figure 8.5 Design of Second Septic Tank with Aeration Chamber

This type of treatment septic tank was introduced by Dr. Uichi Inoue, professor of Waseda University in Japan in 1964. This system can reduce 65~74% of the BOD through the anaerobic chamber of septic tank without using electrical power. The aeration chamber will be filled with charcoal filter produced in the village as a bio-filter.

(3) Dual Treatment System

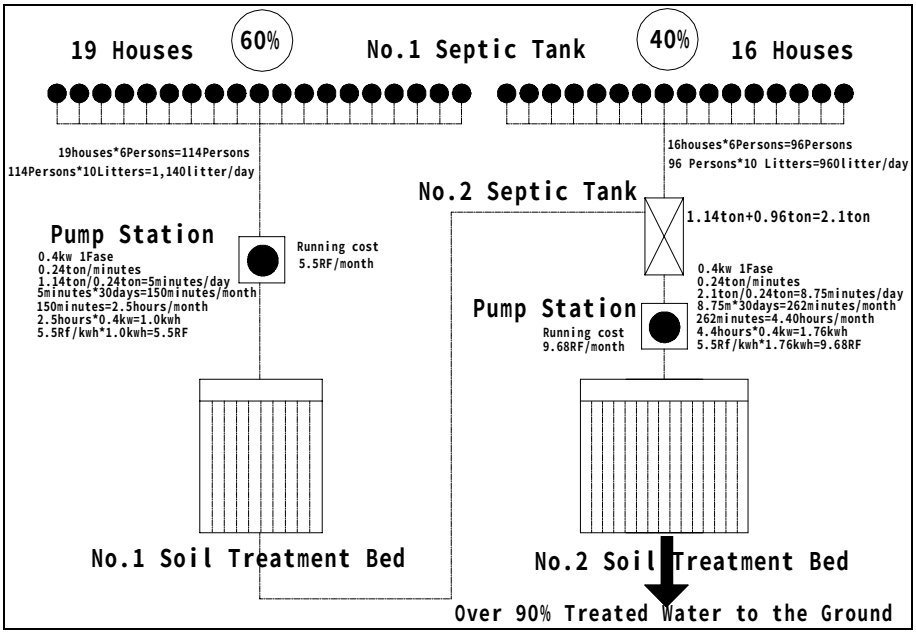


Figure 8.6 Diagram of Dual Treatment System

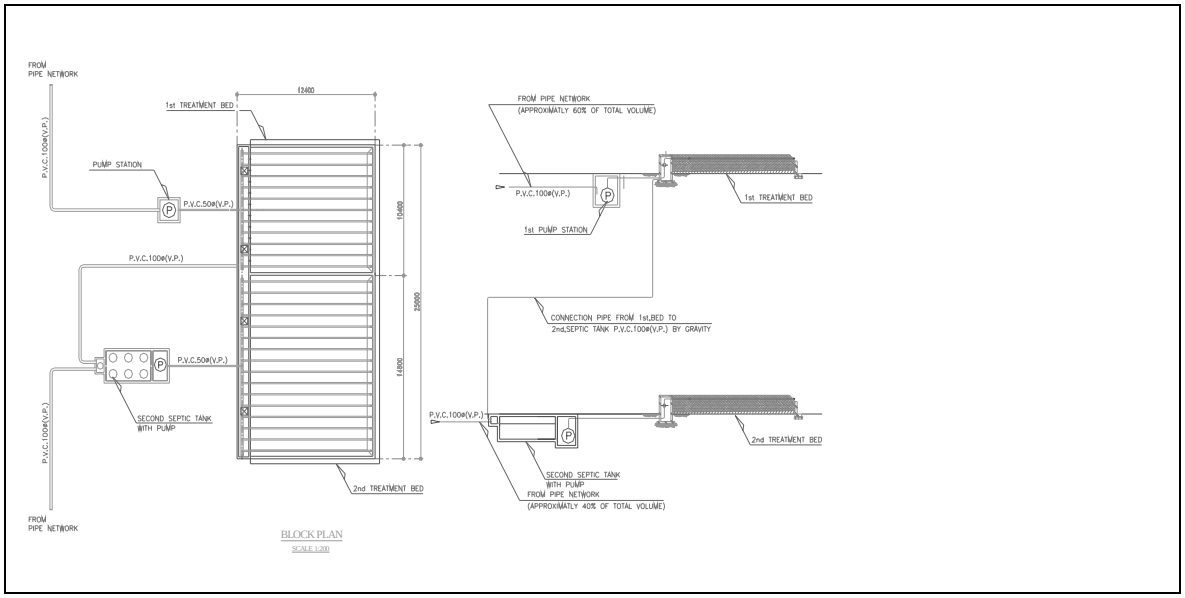


Figure 8.7 Design of Dual Treatment System

This system was introduced by Dr. Tomoaki Itayama, National Institute for Environmental Studies in Japan, as the Two Step Soil Trench Treatment System. This system can reduce 98% of BOD.

In this system, Home Type Septic Tank (Figure 8.8), 2nd Septic Tank (Figure 8.9) and the above mentioned Dual Treatment System are combined to form a Multi-step Treatment System. The expected removal rate of BOD will be 90~99%. After completing all treatment process, effluent will be discharged into the ground. Therefore, there will be no water loses, except loss through vaporization during treatment process.

(4) Treatment of High-Grey Water

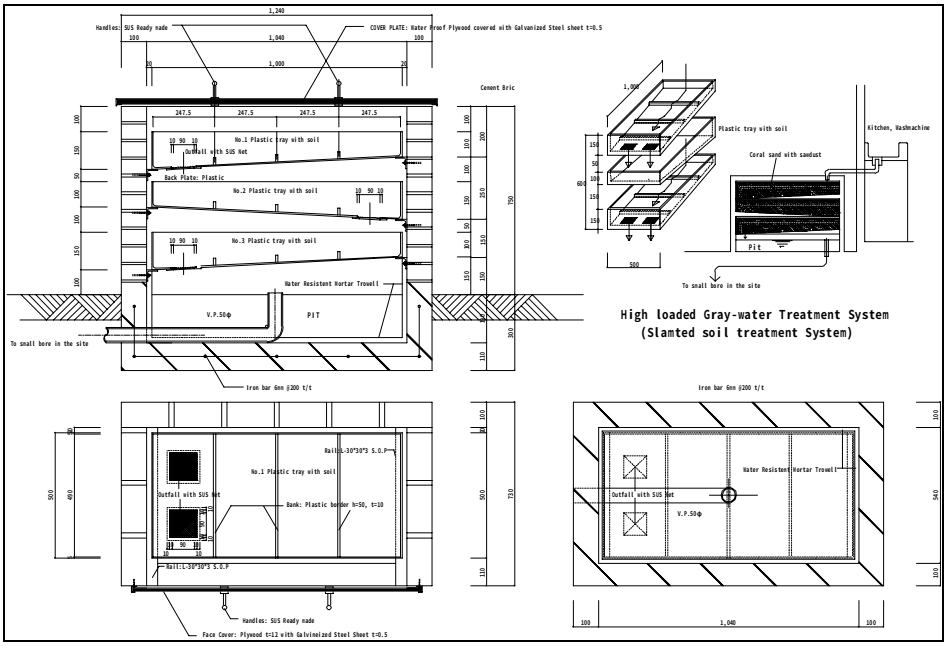


Figure 8.8 Treatment Method of High-grey Water

Slanted Soil Treatment System will be used to treat high-grey water from kitchen and washing by the same method of multi-step soil treatment system. Three slanted plastic tray are installed mutually as shown in the Figure 8.11, which is filled with soil or coral sand. The high grey-water from the sink is poured into the top of the three piling treys. The water flows through the soil in the tray and will be treated by aerobic bacteria, as well as anaerobic bacteria, which grows behind the 3 bar setting of the tray. The process will be repeated three times. Dr. Itayama estimates a reduction rate of BOD of over 99%. After treatment, effluent will be discharged to the ground through existing penetrating hole.

(5) Desludging

To keep the septic tank functional, desludging of the septic tanks is necessary. However, people will avoid such unhygienic work without any equipment or incentives. Therefore, an organization should be established to conduct operation and maintenance of the sewerage system, including desludging of septic tanks. In preparation of this situation, construction of drying bed and procurement of desludging devices will be included in the project.

(6) Drying Bed

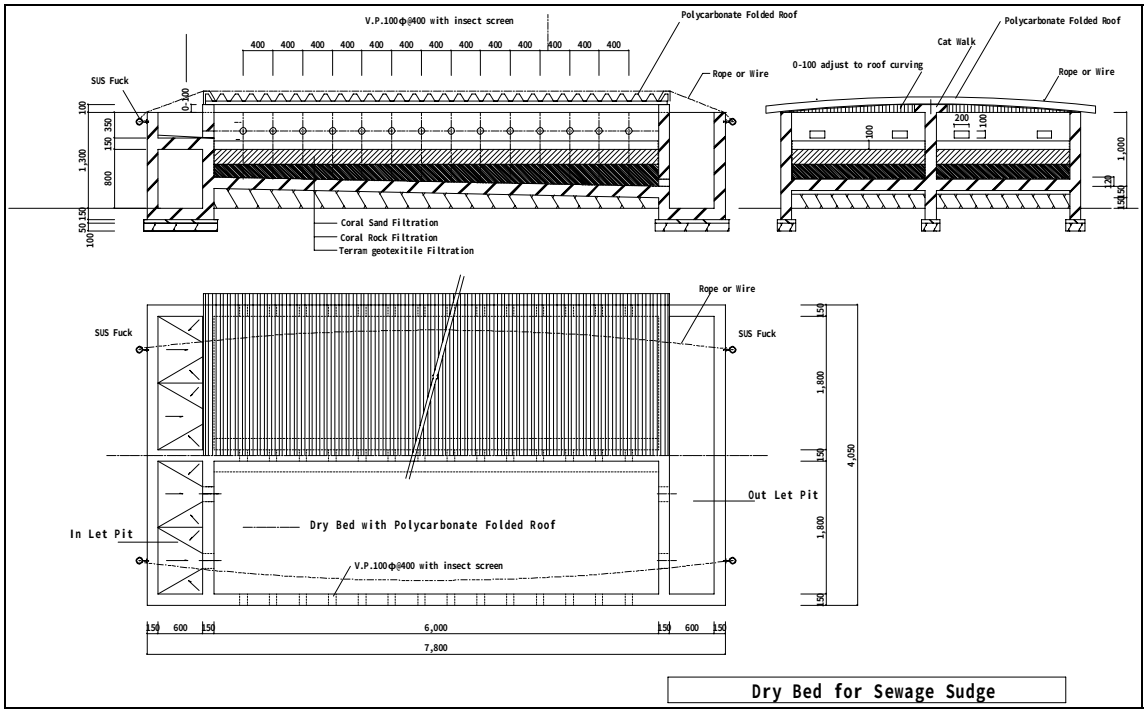


Figure 8.9 Diagram of Drying Bed

The design of drying bed is shown in Figure 8.9. One unit consists of two drying beds filled with coral sand and rock. The dimension of the bed is 6.0m x 1.8m. One bed can treat 2.5 ton sewage sludge in one time. It takes 7 days to dry sludge completely. So, one unit can treat 4 house's

sludge per 1 week, since the volume of home septic tank is 1.5 ton. That means one unit can treat 212 septic tanks per year. Therefore, Isdhoo area (202 household) and Isdhoo-Kalaidhoo area (138 household) have one unit each. The roof on the beds is made of polycarbonate transparent sheet to heat and dry beds. This roof also protects dry bed from rain. For convenience, when someone needs to take out the soil, the roof can be easily removed.

(7) Vacuum Car

Vacuum car (vehicle with desludging machine and tank) was required from MWSA. But the Team could not obtain any specification. The Team is looking for a suitable vacuum car in Sri Lanka.

8.3.5 Facility List

Table 8.3 Sewerage System Facility List of Site 1 Isdhoo-Kalaidhoo Area (Except Relocation Area)

	Items	Quantity	Note
1	150φV.P. Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	M	Existing road： Sand compaction finish
2	100φV.P.	M	From toilet until main piping using 100φ
3	50φV.P.	M	From pump station to Reach Field
4	Junction box 150φ	pc	
5	Home type Septic Tank 1.5ton	88+8pc	FRP type
6	Communal Septic Tank 2.5ton	7pcs	FRP type
7	Connection work to existing pipe	0pc	Recipient side matter
8	Communal Septic tank 25ton	1pc	School
9	Connection work to existing pipe	0pc	Recipient side matter
10	Sewage pump station with pit	20pc	
11	Sewage pump D40A-2, 220/250V, 50Hz, 3.5A, 1φ0.4kw	20pc	DAVEY40 or equivalent Sewage Pump
12	2nd Septic Tank with pump	5pc	Aeration chamber with charcoal filter
13	Mounted Leach Field Dual Step Treatment Bed	5pc	
14	Sludge Drying Bed with polycarbonate folded roof, 2 units	1unit	
15	Slant soil treatment system	88+8pcs	1pc for 1facility except school Total number will be changed according to increasing number of home-type septic tank
16	Connection work to existing pipe	0pc	Recipient side matter
17	Electrical works	1unit	Power supply from existing distribution board to newly installed panel is recipient side matter
18	Vacuum car	0unit	
19	Others	1unit	

Table 8.4 Sewerage System Facility List of Site 1 Isdhoo-Kalaidhoo Relocation Area

	Items	Quantity	Note
1	150φV.P. Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	M	Existing road： Sand compaction finish
2	100φV.P.	M	From toilet until main piping using 100 φ
3	50φV.P.	M	From pump station to Reach Field
4	Junction box 150φ	Pc	
5	Home type Septic Tank 1.5ton	42pc	FRP type
6	Communal Septic Tank 2.5ton	0pcs	FRP type
7	Connection work to existing pipe	0pc	Recipient matter
8	Communal Septic tank 25ton	0pc	
9	Connection work to existing pipe	0pc	Recipient matter
10	Sewage pump station with pit	4pc	
11	Sewage pump D40A-2, 220/250V, 50Hz, 3.5A, 1φ0.4kw	4pc	DAVEY40 or equivalent Sewage Pump
12	2nd Septic Tank with pump	2pcs	Aeration chamber with charcoal filter
13	Mounted Leach Field Dual Step Treatment Bed	2pc	
14	Sludge Drying Bed with polycarbonate folded roof, 2 units	0pc	
15	Slant soil treatment system	42pcs	1pc for 1facility except school Total number will be changed according to increasing number of home-type septic tank
16	Connection work to existing pipe	0pc	Recipient matter
17	Electrical works	1unit	Power supply from existing distribution board to newly installed panel is recipient side matter
18	Vacuum car	0unit	
19	Others	1unit	

Table 8.5 Sewerage System Facility List of Site 2 Isdhoo Area

	Items	Quantity	Note
1	150φV.P. Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	M	Existing road： Sand compaction finish
2	150φV.P.	M	From toilet until main piping using 100φ
3	50φV.P.	M	From pump station to Reach Field
4	Junction box 150φ	Pc	
5	Home type Septic Tank 1.5ton	184+18pc	FRP type
6	Communal Septic Tank 2.5ton	6pc	FRP type
7	Connection work to existing pipe	0pc	Recipient matter
8	Communal Septic tank 25ton	1pc	School
9	Connection work to existing pipe	0pc	Recipient matter
10	Sewage pump station with pit	24pc	
11	Sewage pump D40A-2, 220/250V, 50Hz, 3.5A, 1φ0.4kw	24pc	DAVEY40 or equivalent Sewage Pump
12	2nd Septic Tank with pump	7unit	Aeration chamber with charcoal filter
13	Mounted Leach Field Dual Step Treatment Bed	7unit	
14	Sludge Drying Bed with polycarbonate folded roof, 2 units	1pc	
15	Slant soil treatment system	184+6pc	1pc for 1facility except school Total number will be changed according to increasing number of home-type septic tank
16	Connection work to existing pipe	0pc	Recipient matter
17	Electrical works	1unit	Power supply from existing distribution board to newly installed panel is recipient side matter
	Others	1unit	

Table 8.6 Sewerage System Facility List of Site 3 Health Centre & Temporary Office Area

	Items	Quantity	Note
1.	150φV.P. Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	M	Existing road： Sand compaction finish
2	100φV.P.	M	From toilet until main piping using 100 φ
3	50φV.P.	M	From pump station to Reach Field
4	Junction box 150φ	pc	
5	Home type Septic Tank 1.5ton	0pc	FRP type
6	Communal Septic Tank 2.5ton	1pcs	FRP type
7	Connection work to existing pipe	0pc	Recipient side matter
8	Communal Septic tank 25ton	0pc	
9	Connection work to existing pipe	0pc	Recipient side matter
10	Sewage pump station with pit	2pc	
11	Sewage pump D40A-2, 220/250V, 50Hz, 3.5A, 1φ0.4kw	2pc	DAVEY40 or equivalent Sewage Pump
12	2nd Septic Tank with pump	1pc	Aeration chamber with charcoal filter
13	Mounted Leach Field Dual Step Treatment Bed	1pc	
14	Sludge Drying Bed with polycarbonate folded roof, 2 units	0pc	
15	Slant soil treatment system	2pcs	Total number will be changed according to increasing number of home-type septic tank
16	Connection work to existing pipe	0pc	Recipient side matter
17	Electrical works	1unit	
18	Vacuum car	1unit	*
19	Others	1unit	

* Vacuum car – 2.0ton Truck Vehicle with 1,600l Vacuum car.

1) 2.0ton Truck Vehicle with flat deck

Length: 4,690mm, Width: 1,690mm, Engine: 2000cc

2) 1,600l Vacuum car with engine

Name: Vacuum car, Type: DV-1600B or equivalent,

Total Length: 3,000mm, Width: 1,390mm, Height: 1,645mm

Tank length: 1,950mm, Width: 1,070, Height: 1,070

Tank Volume: 1,600l, Weight: 500kg, Total Weight: 2,100kg

Vacuum Pump: -0.067Mpa(50cmHg), 0.06Mpa(0.6kg/cm2)

Pump Capacity: Sack 1,000l/min, Discharge 700l/min

Engine: 2.9~4.4kw (4PS~6PS)

Hose: Sacking hose 20m, Discharge hose 4m

8.4 Cost Estimation

The estimated project cost of the sewerage system at the design stage is as shown in Table 8.7 ~ 8.8

8.4.1 Isdhoo Area

Table 8.7 Cost Estimation of Isdhoo Area

			Unit price (US$)	Cost (US$)
1.	150φV.P. (10%loss included) Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	7,760m	25	194,000
2	150φV.P. (10%loss included)	275m	35	9,625
3	50φV.P. (10%loss included)	1,250m	20	25,000
4	Junction box 150φ	658pc	40	26,320
5	FRP home type Septic Tank 1.5ton	184pc	750	138,000
6	FRP Communal Septic Tank 2.5ton	6pc	750	4,500
7	Connection work to existing pipe	0pc	100	0
8	Communal Septic tank 25ton	2pc	4,500	9,000
9	Connection work to existing pipe	0pc	500	0
10	Sewage pump station with pit	24pc	850	20,400
11	Sewage pump D40A-2, 220/250V, 50Hz, 3.5A, 1φ0.4kw	24pc	400	9,600
12	2nd Septic Tank with pump	7	2,900	20,300
13	Mounted Leach Field	14pc	11,000	154,000
14	Sludge Drying Bed with polycarbonate folded roof, 2 units	1pc	9,000	9,000
15	Slant soil treatment system	190pc	200	38,000
16	Connection work to existing pipe	0pc	50	0
17	Electrical works	1		5,500
	Others	1		65,000
	Sub total			728,245
	Contingencies			82,255
	Site expense			80,000
	TOTAL			890,500

8.4.2 Isdhoo-Kalaidhoo Area

Table 8.8 Cost Estimation of Isdhoo-Kalaidhoo Area

			Unit price (US$)	Cost (US$)
1.	150φV.P. (10%loss included) Pipe with connection, leveling 1/200 Refilling, Finishing of road surface	6,920m	25	173,000
2	150φV.P. (10%loss included)	135m	35	4,725
3	50φV.P. (10%loss included)	1,090m	20	21,800
4	Junction box 150φ	602pc	40	24,080
5	Home type Septic Tank 1.5ton	130pc	750	97,500
6	Communal Septic Tank 2.5ton	7pcs	750	5,250
7	Connection work to existing pipe	0pc	100	0
8	Communal Septic tank 25ton	2pc	2,500	5,000
9	Connection work to existing pipe	0pc	500	0
10	Sewage pump station with pit	20pc	850	17,000
11	Sewage pump	20pc	400	8,000
12	2nd Septic Tank with pump	8pc	2,900	23,200
13	Mounted Leach Field	15pc	11,000	165,000
14	Sludge Drying Bed	1pc	9,000	9,000
15	Slant soil treatment system	137pcs	200	27,400
16	Connection work to existing pipe	0pc	50	0
17	Electrical works	1		5,500
18	Vacuum car	1unit	40,000	40,000
19	Others	1		60,000
	Sub total			686,455
	Contingencies			68,045
	Site expense			70,000
	TOTAL			824,500

NOTE: This cost estimation does not include recent cost escalation.

The tender price at the contract were 210,000,000 Yen (or 1,750,000 US$).

8.4.3 Operation and Maintenance Cost

(1) Isdhoo Area

Running Cost (Power consumption and Pump replacement):

1) Power consumption
   (5.5+9.68)/2*1.5=11.385Rf/pump/month
   (24+0.5)*11.5=281.75Rf/month
   281.75/month*12months*3years=10,143Rf---------A
2) Pump replace(3years each)
   300USD*12.75Rf*24.5pumps=93,712.5Rf----------B
   A+B=103,855.5Rf/3years
   103,855.5/3years/12month=2,884.875/month------(1)

Operation and Maintenance cost (Manpower and Desludging Equipment):

3) Manpower
   3ps*2,000Rf=6,000Rf/month----------C
4) Office running cost
   1,000Rf/month----------D
5) Replace of Desludging Equipment
   360,000Rf/10years=36,000Rf/year=3,000Rf/month
   3,000Rf/5*3Areas=1,800Rf/month----------E
   C+D+E=8,800Rf/month----------(2)

Total Cost:
   (1)+(2)=11,684Rf/month

Share of one house holder:
   11,684Rf/186householder=62.817Rf
   =About 63Rf/month

(2) Isdhoo-Kalaidhoo Area

Running Cost (Power consumption and Pump replacement):

1) Power consumption
   (5.5+9.68)/2*1.5=11.385Rf/pump/month
   (20+0.5)*11.5=235.75Rf/month
   235.75/month*12months*3years=8,487Rf----------A
2) Pump replace(3years each)
   300USD*12.75Rf*20.5pumps=78,412.5Rf----------B

A+B=86,899.5Rf/3years
86,899.5/3years/12month=2,413.875/month

Operation and Maintenance cost (Manpower and Desludging Equipment):

3) Manpower
2ps*2,000Rf=4,000Rf/month----------C
4) Office running cost
800Rf/month----------D
5) Replace of Desludging Equipment
360,000Rf/10years=36,000Rf/year=3,000Rf/month
3,000Rf/5*2Areas=1,200Rf/month----------E
C+D+E=6,000Rf/month----------(2)

Total Cost:
(1)+(2)=8,513Rf/month

Share of one house holder:
8,513Rf/130householder=65.48Rf
=About 66Rf/month

(3) Expected Income

For example, in Gan island, a farmer uses fertilizers of cow feces imported from India. It costs 1 US$ per 1 kg. The farmer grows vegetables using this fertilizer and sells the product to the resort hotels in Maldives. According to the farmer the cost is well balanced. If the organization of the new sewerage system can create new market in Isdhoo, they can sell the fertilizer made from human feces. The calculated price is 2Rf/kg. It is 1/6 cheaper than Indian fertilizer.

Expected product of fertilizer in Drying Bed:

130+184=314 houses (Isdhoo+Isdhoo-Kalaidhoo)/2years
157 houses/year×300kg=47,100kg/year
47,100kg×2Rf=94,200Rf/year

Total Income=94,200/year
Total Outgo=87,000+102,000=189,000/year
Total Outgo-Total Income=189,000Rf-94,000Rf=95,000Rf/year

So, there is the possibility of reduction of the payment as below:
95,000Rf/(130+184)=302.55Rf/year par one householder
302.55Rf/12month=25.21Rf/month

8.5 Construction and Implementation Plan

The schedule of the pre-qualification. tendering and construction are as follows:

1) P/Q 2 August, 2005
2) Tender Opening 5 December, 2005
3) Award and Contract 9 November, 2005
4) Construction Period Mid-November 2005 to early July 2006

The tender and construction schedule will start in the middle of Oct. 2005 and should be completed by the end of June 2006. Table 8.9 – 8.11 shows the Scope of Work and shares to be born by the responsible organizations of GOM and Japan.

Table 8.9 Construction of Facilities

	Item	GOM	Japan
1	Construction of septic tank		○
2	Construction of sewer piping network		○
3	Construction of intermediate pump station		○
4	Construction of mounted leach field		○
5	Construction of 2nd septic tank with pump station		○
6	Demolish of existing septic tank if necessary	○	
7	Connection from existing toilet to installed septic tank	○	
8	Construction of new water treatment facility		○
9	Construction of sludge drying bed		○
10	Installation of pumps		○
11	Coordination during connection work between the existing pipes and newly installed pipes	○	

Table 8.10 Provision of Equipment

	Item	GOM	Japan
1	Equipment for water quality test		○
2	Equipment for sludge discharge		○
3	Equipment for water quality test		○
4	Equipment for charcoal production		○

Table 8.11 Others

	Item	GOM	Japan
1	Acquisition of approval, permission or etc. from the Authorities; Road crossing work Electricity work Any other work which require approval, permission etc.	○	
2	Land acquisition for treatment facilities and temporary office	○	
3	Grass-cutting in the water treatment plant	○	
4	Construction of fence and its gate	○	
5	Coordination during water cutoff	○	
6	Information on buried facilities and attendance to excavation work	○	
7	Free water supply to pipe-flushing (washing)		○
8	Electrical work up to incoming panel (included)	○	
9	Trial excavation		○

10	Pipe-flushing work		○
11	Leak-detection tests of septic tanks and piping network		○
12	Charcoal production	○	

8.6 Recommendations

(1) To examine and select best construction measure for Septic tank

To examine FRP Up-flow Type Septic Tank (According to the comparison study with MEEW, FRP type is better than concrete type in durability, water proof and workability, so we select FRP type septic tank.)

To examine construction method of 2nd Septic Tank with depth over 2.5m to secure ground water (To protect ground water we have changed the design the depth from 2.5m to 1.5m)

(2) Using debris of the devastated area for the construction of the system

To use it for Up-flow filter in Home Type Septic Tank

To use it for the retaining wall for Mounted Leach Field

To use it for the filtration of Mounted Leach Field

To use it gravel for the foundation of the facilities

(3) Using local labor for the construction stage of the project

To use them as worker in the construction

To use 3~6 persons as assistant manager on the project site

(Both Island Office has already select the member of the candidates)

(4) Using local made charcoal as the bio-filter for the system

To use local made charcoal as the bio-filter for the 2nd Septic Tank Aeration Chamber

To use it for the filtration of Mounted Leach Field and Drying Bed

To use it for the filtration for the other facilities

(Both Island Office promised to produce and offer charcoal to the contractor with appropriate price)

(5) To promote charcoal using system in the village

To install charcoal processing device

To provide charcoal using chance

(6) Capacity Building of Operation and Maintenance

To learn how to work the system through construction stage

To learn how to maintain the system through construction stage

To learn how to maintain the system through and making operation manual

(7) Environmental Monitoring of the Groundwater

To use new organization for monitoring

(Sampling ground water from existing well and send sample to central office)

To install monitoring devices to central office in MEEW

(Ph meter, COD and BOD measurement equipment, CO2 incubator, microscope, etc)

CHAPTER 9 ALTERNATIVE COMMUNICATION AND NETWORK

9.1 Introduction

9.1.1 Background

The Maldives comprises a long, narrow chain of atolls that are located in the northern Indian Ocean. This small nation extends approximately 800 km from the northernmost tip to the southernmost tip and it contains about 1190 islands. The exclusive economic zone of the Maldives covers about 859,000 km^2. The capital is Male', and from here the other island communities are administered through a total of 20 local Atoll Offices. The island communities are widely dispersed, so communications within the Maldives, and with the rest of the world, are totally dependent on public telephone services. If the public telephone network is out of service, then communications are not possible. This presents a very serious problem in emergency situations, such as tsunami and typhoons.

On December 26, 2004 a major earthquake (M9.0), occurred in the Indian Ocean near the Indonesian island of Sumatra. The resulting tsunami caused extensive damage in the Maldives, including the telecommunications network. The Maldives telecommunications infrastructure is based on a terrestrial microwave network backbone. This network consists of 37 nodes. The tsunami disaster damaged 5 of these nodes and telecommunication services to 13 atolls (comprising 168 separate islands) were disrupted.

Dhiraggu, which is the sole telecommunications operator in the Maldives, started work on restoring the telephone network immediately after the tsunami. As a result, telecommunication services were restored within 3 weeks. However, the Maldives government does not have an alternative communications network that can be used when the pubic telephone network is damaged. Moreover, when an aftershock related to the Sumatra earthquake occurred on March 29, 2005, it was reported that some telephone calls could not be made. This was due to line congestion caused by the increased traffic resulting from emergency calls.

Based on the above circumstances, the government of the Maldives has decided to develop an alternative communications network, which is not affected by disasters.

9.1.2 Objectives of the Study

The objectives of the study are to make an optimal development plan for an alternative communications network, including a disaster warning system, to increase the comprehensive natural disaster management capability of the Maldives. This study also incorporates the experience and lessons learned from Japanese disaster prevention procedures.

The study includes:

1) Assessment of the current condition of telecommunications in the Maldives,
2) Analysis of the impact of the December 26 tsunami on telecommunications,
3) Formulation of a disaster prevention plan for the Maldives,
4) Preliminary design and cost estimation for an alternative communications system,
5) Preparation of a preliminary implementation schedule for the system, and
6) Recommendations for the system implementation.

9.2 Telecommunications in the Maldives

9.2.1 Transformation of Telecommunication Services

The telecommunication service in the Maldives was officially started when a wireless telegraph radio circuit was set up between the Maldives and Sri Lanka in 1943. Dedicated telephone services were later introduced in the country in 1968 with the capacity of 20 lines via a manual exchange.

The tourism industry of the Maldives started in 1972. Tourism boosted the demand of international telecommunication services. As a result of the rapidly growing demand for both local and international telecommunication, the first automatic telephone exchange, with the capacity of 300 lines, was installed in Male' in 1972. In 1973, the first international earth station (NEC standard B) came into operation, giving the general public access to international telecommunication services.

Major milestones in the history of the Maldives telecommunication services include the following:

1943 Telecommunications services officially started in the Maldives.
1967 Radio telephone service introduced to two atoll capitals.
1968 Public telephone service introduced into Male'.
1977 First Maldives earth station
1988 Telecommunications public enterprise, Dhivehi Raajjeyge Gulhun Private Limited (Dhiraagu), established.
1991 Paging services introduced.
1993 Public card phone service launched.
1996 Internet services introduced.
1997 Dhiraagu Mobile Phone Service "DhiMobile" (with AMPS) introduced.
1998 Cyber Café opened in Male'.
1999 Telephone services to cover all inhabited islands.
GSM mobile services commenced.
2000 International GSM roaming services launched
Internet dial-up access at up to 56 kbps introduced
DhiMobile Data, Fax services introduced

2001 GSM coverage expanded to cover Baa and Lhaviyani atolls (all resorts and the main inhabited islands).
DhiMobile SMS service launched.
DhiMobile VoiceMail service launched.
2002 DhiveNet Broadband with ADSL introduced.

9.2.2 Relevant organization

Responsibility for the formulation and promulgation of telecommunication policy in the Maldives lies with the MTC, which discharges its responsibilities through the Telecommunications Authority of Maldives (TAM). Under the TAM, there is an organization named Dhivehi Raajjeyge Gulhun Private Limited (Dhiraagu) which operates the actual telecommunication services as a public enterprise. The organization chart of relevant entities is shown in Figure 9.1.

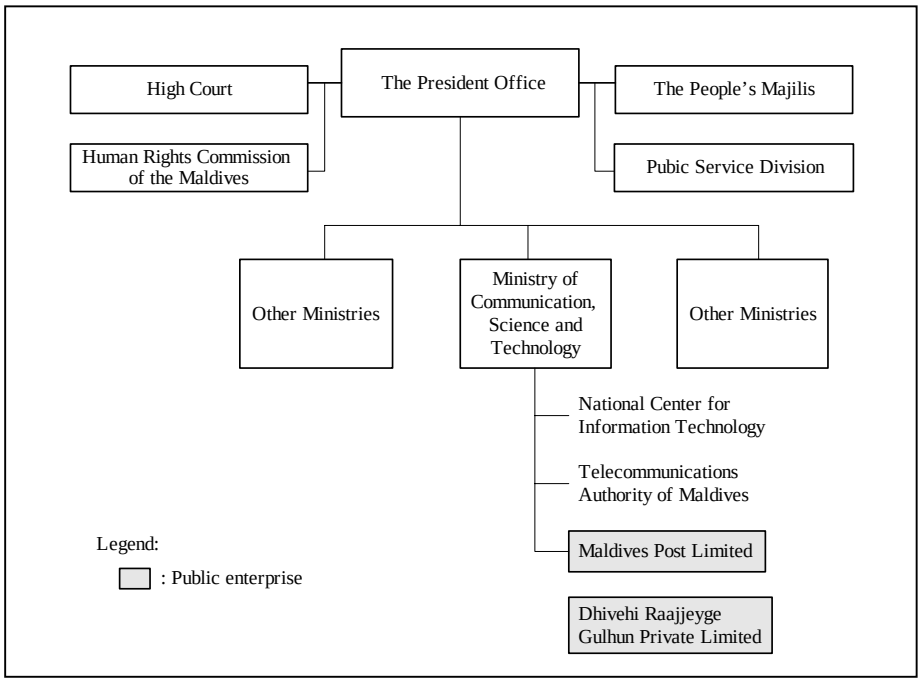


Figure 9. 1 Organization Chart of the Maldives Telecommunication Sector (as of June, 2005)

9.2.3 Telecommunication operator and services

Dhivehi Raajjeyge Gulhun Private Limited (Dhiraagu), which is the sole telecommunication operator in the country, was founded and registered in 1998. Dhiraagu is a joint venture company with 55% of its share owned by the government of the Maldives and 45% by Cable and Wireless

plc. of the United Kingdom. Dhiraagu provides fixed local and long distance telephone services, international telephone services, GSM cellular mobile services, packet switch services and Internet services as follows:

1) Fixed line services: local, long-distance, international
2) Public phone services: Smartcard based public card phone
3) Mobile services: GSM post-paid and pre-paid, Short Massage Service (SMS), Voice Mail, Fax Mail
4) Internet or data services: Dial-up, ISDN, ADSL, Web hosting
5) Leased line services: local, national and international digital leased circuits

The following table provides the telecommunications indicators and telephone density in the Maldives. It clearly shows that the availability of telephone lines in areas outside of Male' is much lower than within Male', proving a considerable imbalance of telephone lines in the nation.

Table 9. 1 Telecommunications Indicators 1999-2003

	1999	2000	2001	2002	2003	Growth rate (1999-2003)
Population	**266,093*1**	**270,101**	**275,975*1**	**280,549*1**	**285,066*1**	**7%**
Male'	-	74,008	-	-	-	-
Other islands	-	196,093	-	-	-	-
Fixed telephone lines	**22,179**	**24,432**	**27,242**	**28,651**	**30,056**	**36%**
Male'	16,787	18,700	20,171	20,964	21,858	30%
Other inhabited islands	4,381	4,800	6,087	6,656	7,127	63%
Resorts	727	810	851	872	883	21%
Uninhabited islands	284	122	133	159	188	-34%
Pay Phones	**579**	**577**	**723**	**769**	**854**	**47%**
Male' and Villingili	104	133	150	158	146	40%
Other islands	475	444	573	611	708	49%
Mobile Phones	**2,776**	**8,387**	**18,433**	**41,899**	**66,466**	**2,294%**
Post-paid	2,776	8,387	11,537	12,274	13,277	378%
Pre-paid	-	-	6,896	29,625	53,189	-
Registered Internet subscribers	939	1,060	1,063	1,067	1,155	23%
Paging subscribers	2,682	2,608	1,824	781	272	-90%
Telex lines	47	46	43	38	38	-19%
Internet usage minutes (000's)	20,020	35,945	43,893	51,358	52,068	160%

Source: Statistical year book of Maldives (2004)

Note: Male' includes Villingili, Aarah, Hulule' & Hulhumale', *1:Mid-year population (estimated)

The growth rate of the respective services for the five years from 1999 to 2003 was 36% for fixed line telephones, 2,294% for mobile telephones and 160% for Internet usage time. While the

number of subscribers to fixed line telephones is increasing slowly, the number of subscribers to mobile phones continues to increase rapidly. Since Dhiraagu started their pre-paid card mobile phone services with the Short Message Service (SMS) function in 2001, the number of subscribers has dramatically increased.

Table 9. 2 Fixed and Mobile Telephone Density (per 100 inhabitants) 1999-2003

	1999	2000	2001	2002	2003
Fixed telephone density	8.34	9.05	9.87	10.21	10.54
Male'	-	25.27	-	-	-
Other island	-	2.92	-	-	-
Mobile telephone density	1.04	3.11	6.68	14.93	23.32
Fixed and mobile telephone density	9.38	12.15	16.55	25.15	33.86

Source: Statistical year book of Maldives (2004)

The World Bank classifies countries according to the GNI per capita. According to this classification, the Maldives is a “Lower middle income” country (US$746-US$2,975). The following table shows the telecommunications density in lower middle income countries of Asia and Oceania in 2002. It is evident from this table that almost all the indices of the Maldives exceed the average in Asia and Oceania.

Table 9. 3 Telecommunications Density in Lower Middle Income Countries in Asia and Oceania (2002)

Country	Internet /100 inhabitants	PC /100 inhabitants	Fixed telephone /100 inhabitants	Mobile telephone /100 inhabitants	Fixed +Mobile /100 inhabitants
1 China	4.60	1.95	16.69	16.09	32.78
2 Turkey	7.28	4.01	28.12	34.75	62.87
3 Thailand	7.75	2.75	9.87	26.04	35.91
4 Philippines	2.50	2.13	4.17	17.77	21.94
5 Iran	1.53	6.87	19.95	3.23	23.18
6 Jordan	4.42	3.21	12.76	16.71	29.47
7 Sri Lanka	1.06	1.32	4.66	4.92	9.58
8 Kazakhstan	0.94	-	12.05	3.62	15.67
9 Syria	0.35	1.59	10.30	1.20	11.50
10 Fiji	2.75	5.00	11.23	10.78	22.01
11 Maldives	5.00	3.33	10.27	15.02	25.29
12 Turkmenistan	0.16	-	8.02	0.17	8.19
13 Vanuatu	2.75	0.10	3.36	0.17	3.53
14 Micronesia	5.00	-	8.67	0.00	8.67
15 Samoa	2.00	0.60	5.70	1.78	7.48
16 Tonga	2.90	1.50	11.31	3.39	14.70
17 Kiribati	2.00	1.00	4.21	0.58	4.79

18 Marshal Is.	0.90	3.00	7.67	0.90	8.57
Average	2.99	2.56	10.50	8.73	19.23

Source: ITU Statistical Year Book (2004)

9.2.4 ICT network

Repeater station at Felidhoo

Figure 9.2 shows the information and communications technology (ICT) trunk network in the Maldives. The Maldives telecommunications infrastructure is based on a terrestrial microwave network backbone. This network consists of 37 nodes. To the north, the network extends from Male' to Dhidhdhoo, Haa Alif Atoll, and to the south, it extends to Gan, Laamu Atoll. The southernmost four atolls (Gaaf Alif, Gaaf Dhaalu, Gnaviyani and Seenu atolls) are connected to Male' via satellite through Hithadhoo, Seenu Atoll. These four atolls are connected to each other through a microwave terrestrial network extending from Hithadhoo to Gaafu Alifu and Gaafu Dhaalu atolls.

Most parts of the network are serially connected through a network of radio repeater stations. The usual network protection with backup facilities, are provided at each of the critical nodes of the network. These include duplication between radio and multiplex equipment and between solar power and standby generators. However, due to the geography of the Maldives, there are difficulties in securing route diversity.

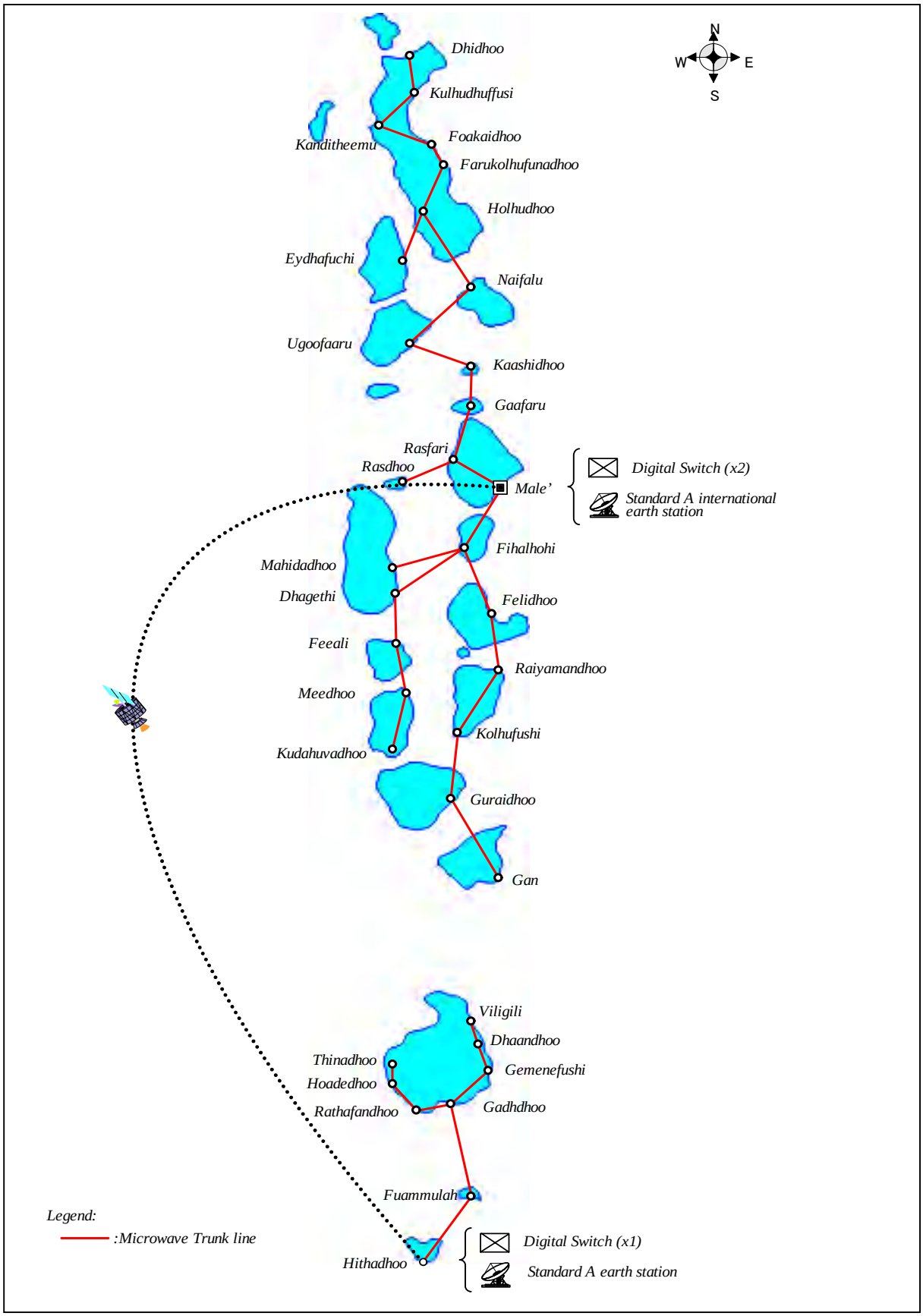


Figure 9. 2 ICT Trunk network in the Maldives

9.2.5 National ICT strategy

ICT national strategies in the Maldives are summarized in both the "Sixth National Development Plan 2001 – 2005" and "Maldives Telecommunication Policy 2001 – 2005". Since this year (2005) is the last year of the 2001 – 2005 policy target, an evaluation of performance is required at the end of the year. However, since a performance index was not specified in the plans, it is hard to make an evaluation at present. These two plans are now being revised for a new target year (2010).

(1) Six National Development Plan 2001 – 2005

In the Sixth National Development Plan (2001- 2005), which was prepared by the Ministry of Planning and National Development, issues and policies with regard to ICT were identified are as follows:

1) Issues

- ✓ Dhiraagu's current system of charging on the minute basis further inflates the cost to be borne by the consumers and is a serious burden especially for businesses and other institutions that make a large number of calls.
- ✓ Presently, telecommunications services in the Maldives are largely concentrated in and around the country's capital. In Male', one in every three persons has a telephone on average, while the ratio in the other areas of the country is one in fifty. Mobile services are limited to Male', North and South Ari Atolls and to certain parts in Lhaviyani Atoll and Baa Atoll. Similarly, Internet services are limited to Male' and a few other islands. This imbalance of access to telecommunications services needs to be urgently remedied.
- ✓ Telecommunications service fees charged in Male' are lower than the fees charged in the rest of the country. Line rental in Male' is Rf.30 per month, while the same service outside Male' is Rf.3,450. Similarly, the phone installation cost in Male' is Rf.1,720 while charges elsewhere vary between Rf.2,990 to Rf.12,650. Such high fees make telephones unaffordable for the majority of people living outside Male'. A significant reduction in such disparity is essential to improve the quality of life and to encourage and facilitate socio-economic development throughout the country.
- ✓ The lack of clear ICT legislative and regulatory mechanisms in the nation has left consumers at the mercy of the service provider. The service provider is also in a position of uncertainty regarding policy and regulatory decisions and is reluctant to invest in projects with long payback periods while attempting to maximize profit with

minimum investment. Comprehensive legislative and regulatory mechanisms are therefore needed to improve the telecommunications sector.

- ✓ Competition is extremely important to improve the quality of services and make services more affordable. While most sectors of the Maldives have been opened up for competition, Dhiraagu maintains a monopoly over most of the telecommunications services. Therefore, opening up the telecommunications sector is necessary to meet the goals of Vision 2020.

2) Policies

- ✓ Make telecommunications services affordable to the public and business sectors at large and reduce the regional disparity in the provision of telecommunication services
- ✓ Improve the regulatory framework governing the telecommunication sector and strengthen consumer rights and protection
- ✓ Explore liberalization of the telecommunications sector by gradually opening up the Internet and mobile service provisions for competition
- ✓ Enhance and promote info-communications facilities and services in the Maldives

(2) Telecommunication Policy 2001 – 2005

In accordance with the national development plan, the MTC formulated telecommunications policies for 2001 – 2005. The policies identify and address key issues in six major areas in order to secure a sustainable development of telecommunication services.

1) Telecommunication charges in the Maldives

Policy: Reduce charges of all telecommunication services.

- ✓ Reduce the disparity in telecommunication charges between Male' and the rest of the country
- ✓ Lower the Internet charges
- ✓ Reduce international call charges
- ✓ Reduce leased line charges
- ✓ Reduce chargeable units
- ✓ Set a cost-related tariff for service provision

2) Telecommunication services outside the capital

Policy: Expand telecommunication services and reduce the disparity in service provision between Male' and other islands.

- ✓ Provide country-wide telephone services on demand on an equal basis
- ✓ Expand mobile telephone service to the whole country
- ✓ Provide high speed Internet services across the country
- ✓ Increase the capacity of international connections

3) Telecommunication regulatory structure

Policy: Provide necessary means and powers to the regulator through an appropriate legislative framework to strengthen the telecommunications sector.

- ✓ Strengthen the legislative framework of the telecommunications sector
- ✓ Distance the regulator from the management of the telecommunications company
- ✓ Enhance and strengthen the regulator

4) Competition in telecommunications services

Policy: Open the telecommunications sector and encourage competition therein.

- ✓ Open telecommunications services for completion
- ✓ Make necessary resources available for telecommunications operators

5) Government revenue from the telecommunications sector

Policy: Make the Government's revenue from the telecommunications sector less dependent on the profit of the sector.

- ✓ Identify additional sources of revenue for the Government from the telecommunication sector

6) Info-communication technology in the Maldives

Policy: Facilitate the use of info-communication technology in all areas of development.

- ✓ Narrow the digital divide within the county

9.3 Impact of Tsunami

9.3.1 Damage by the December 26, 2004 Tsunami

Several telecommunication facilities were damaged by the tsunami that occurred on 26th December, 2004. At around 09:25, the Dhiraagu remote network monitoring centre reported that network nodes at Gaafaru (Kaaf Atoll), Raiymandhoo (Meemu Atoll), Meedhoo (Dhaalu Atoll), and Gadhdhoo (Gaaf Dhaalu Atoll) had failed. The failure of these nodes resulted in the disruption of all public telecommunication services to 13 atolls (163 inhabited islands). The stricken atolls in the north were Haa Alif (HA), Haa Dhaalu (HDh), Shaviyani (Sh), Noonu (N), Raa (R), Baa (B) and Lhaviyani (Lh), and in the south were Meemu (M), Dhaalu (Dh), Thaa (Th) and Laamu (L). In the far south, Gaaf Alif (Ga) and Gaaf Dhaalu (GDh) were also affected.

The reasons why the telecommunication network was disrupted are presumed to be as follows:

1) Short circuit of equipment due to the tsunami, and
2) Both the commercial and the telecommunications station power supplies were disrupted.

In addition to the damage to the telecommunications nodes, many of the telephone booths were also devastated by the tsunami.

Dhiraagu's technical team reported major damage to the facilities when they visited the damaged

sites for repair work on 26th December. This damage is highlighted in the following photos:

(1) Gaafaru, Kaafu Atoll

The equipment room/hut was standing, but the perimeter wall was destroyed. The power generator and batteries were damaged due to flooding caused by sea water. The radio equipment was partly submerged, but has now been repaired.

Gaafaru Equipment Room

(2) Gadhdhoo, Gaaf Dhaalu Atoll

The equipment room/hut was standing, but the perimeter wall was destroyed. The power generator and batteries were damaged due to flooding caused by sea water. The radio equipment was submerged, but has now been repaired.

Gadhdhoo site boundary **destroyed**

(3) Raiymandhoo (Meemu Atoll)

The site suffered significant damage. The perimeter wall, solar panels and structure were destroyed. The power and equipment room was directly hit by the tsunami. Equipment racks were displaced and all power and radio equipment was completely destroyed.

Raiymandhoo mast guy base

Raiymandhoo building supporting pillars

Raiymandhoo equipment shelter

Raiymandhoo building

(4) Kolhufushi (Meemu Atoll)

The equipment room/hut was standing, but the perimeter wall was destroyed. The power generator and batteries were damaged due to flooding caused by sea water. However, water did not reach the radio equipment.

Kolhufushi Booth

Kohufushi Generator

(5) Muli (Meemu Atoll)

No major problems were reported for the site. However, there was no commercial power.

(6) Meedhoo (Dhaalu Atoll)

The equipment room/hut was standing, but the perimeter wall was destroyed. The power generator and battery were damaged due to flooding caused by sea water. The microwave and mobile radio were equipment destroyed.

9.3.2 Restoration Work

Dhiraagu started the restoration work immediately after the tsunami, as is described below. A Network Crisis Management Team was established, which coordinated its work with the Telecommunication Authority of Maldives during the restoration process.

a) Within 24 hours, telephone services were restored to 9 of the 13 atolls that had been disconnected.
b) Within 72 hours, telephone services had been restored to all the atolls.
    - A total of 164 inhabited islands are normally connected to telephone services. Except for 6 islands, which had no communications facilities, the other islands could use VHF/CB radios to communicate with atoll offices where telephone services were operational.
c) Mobile services were totally restored 12 days after the disaster.
d) Within 3 weeks, the telecommunications network was totally restored, except for evacuated islands, to the same as the pre-tsunami situation.

As mentioned above, public telecommunication services have now been restored to the pre-tsunami disaster service level.

9.4 Alternative Communication and Network Development

9.4.1 Necessity for an Alternative Communications and Network System

Based on previous studies, the necessity for an alternative communications and network system are specified in the following sections. Communications in the Maldives is dependent on public telephone services. Because of this, each island is not able to communicate with other places when the public telephone network is out of service.

On 26th December, 2004 a major earthquake (M9.0), occurred in the Indian Ocean near Sumatra. The resulting tsunami caused extensive damage in the Maldives. The Maldives telecommunications infrastructure is based on a terrestrial microwave network backbone. This network consists of 37 nodes. Due to the tsunami disaster, 5 nodes were damaged and telecommunication services in 13 atolls (comprising 168 separate islands) were disrupted.

Dhiraggu, which is the sole telecommunications operator in the Maldives, started restoration work immediately after the tsunami. As a result, telecommunication services were restored as follows:

i) within 24hrs, telephone services were restored to 9 out of 13 affected atolls
ii) within 72hrs, telephone services were restored to all atolls, but with limited operating conditions
iii) within 3 weeks, telephone services were totally restored

The GOM does not have an alternative communications network that can be used when the pubic telephone network is damaged. Moreover, when an aftershock related to the Sumatra earthquake occurred on March 29, 2005, it was reported that some telephone calls could not be made. This was due to line congestion caused by the increased traffic resulting from emergency calls.

Based on the above circumstances, it is concluded that an alternative communications network, which is not affected by disasters, needs to be developed.

In addition to the above, the necessity for developing an alternative system was specified in project code DRM005 of the National Recovery and Reconstruction Plan (NRRP) prepared by the Ministry of Planning and National Development (MPND) in March, 2005.

9.4.2 Objective and Required System Functions

The objective of the system is to develop an alternative communications network, including early an emergency early warning system, to increase the comprehensive natural disaster management capability of the Maldives. In order to realize the above and maximize the project benefit, the following components are required:

1) Development of a dedicated communications system, and

2) Development of emergency early warning system (for typhoons, tsunami, etc.).

To minimze operation and maintenance costs and balance the initial investment cost and performance, the study team proposes 4 functions:

i) Multiplex radio system

ii) Digital HF radio system,

iii) Trunked line radio system

iv) VHF emergency early warning system.

The system concept is shown in Figure 9.3.

The dedicated communications system consists of a digital HF radio system, multiplex radio system and VHF trunked line system, which are needed for the purpose of data and voice communication. In addition, a VHF early warning system consisting of master equipment, remote equipment, loudspeakers and VHF radio system is needed. Table 9.4 shows the general functions required for each system.

Table 9. 4 General Required Function of Each System

	Name of system	Required function
1	Multiplex radio system	Allow communication between related organizations in Male'. • Communication information: Voice and data (Fax, message)
2	Digital HF radio system	Allow long distance communication between Male' and atoll offices. • Communication information: Voice and data (Fax, message)
3	Trunked line radio system	Allow: 1) Communication between atoll offices and island offices, and 2) Mobile communication in atolls and island, including communication between administrative offices and vessels, such as local fishing boats (yatra-doni). In cooperation with Digital HF radio, island offices would communication with Male' thorough atoll offices. • Communication Information: Voice and data (Fax, message)
4	VHF emergency early warning system	In cooperation with Digital HF radio, the VHF emergency early warning system will allow automatic and manual announcement of emergency evacuation warnings. The commands should be generated from Male' or from either Atoll or Island offices. An interrupt function will allow the loud speaker system to be used for administrative communication to local residents when no emergency is imminent. • Communication Information: data (command) and voice.

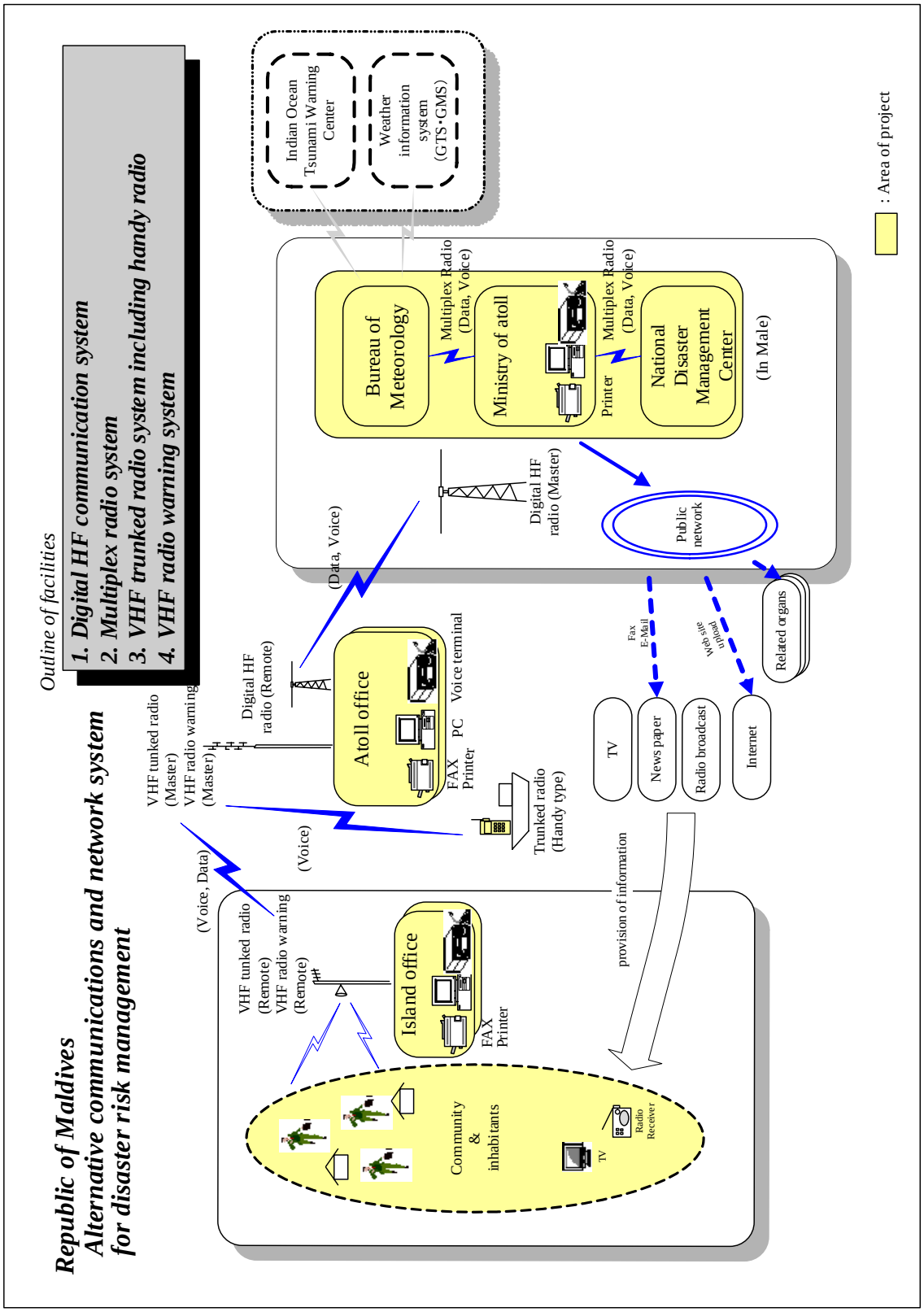


Figure 9. 3 System Concept

9.4.3 Relevant organization and disaster prevention plan

In the Maldives there are currently no protocols for natural disaster prevention, such as announcing evacuation orders. In contrast, Japan has long had such protocols. The first Japanese Disaster Measures Basic Plan was prepared in 1963, and it is based on Japan's Disaster Measure Basic Law. Since it was first introduced, the Japanese plan has been revised, based on experiences and lessons from disasters such as the Kobe earthquake, etc. This plan provides fundamental guidelines for disaster prevention in Japan, and covers earthquakes, floods, tsunami, volcanic disasters, snow disasters, marine disasters, aviation disasters, rail disasters, road disasters, nuclear disaster, etc.

In the Japanese Disaster Measures Basic Plan, related organizations are classified into three levels, as indicated in Figure 9.4 below:

1) National level
2) Regional level, and
3) Municipal level.

The organization of the national level is further classified into the appointed government organizations and other appointed administrative organizations. Figure 9.5 shows the disaster prevention organization network in Japan.

The appointed governmental agency consists of the Prime Minister's Office, Cabinet Office, Ministry of Public Works, Fire Defense Agency, Meteorological Agency, Coast Guard, etc. In addition, the other appointed administrative organizations consist of independent administrative agencies such as research institutes, public corporations having responsibility for roads, post and telecommunications, and also broadcasting operators, power companies and telecommunications operators, etc.

As for the regional level organization, there are regional government and branch office of national level organizations. Municipal level organizations include fire stations which perform rescue operations, hospitals, schools, police stations and regional disaster management organizations.

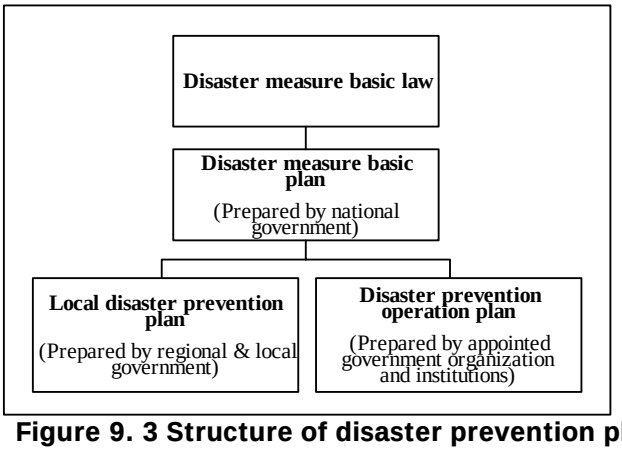


Figure 9. 3 Structure of disaster prevention plan

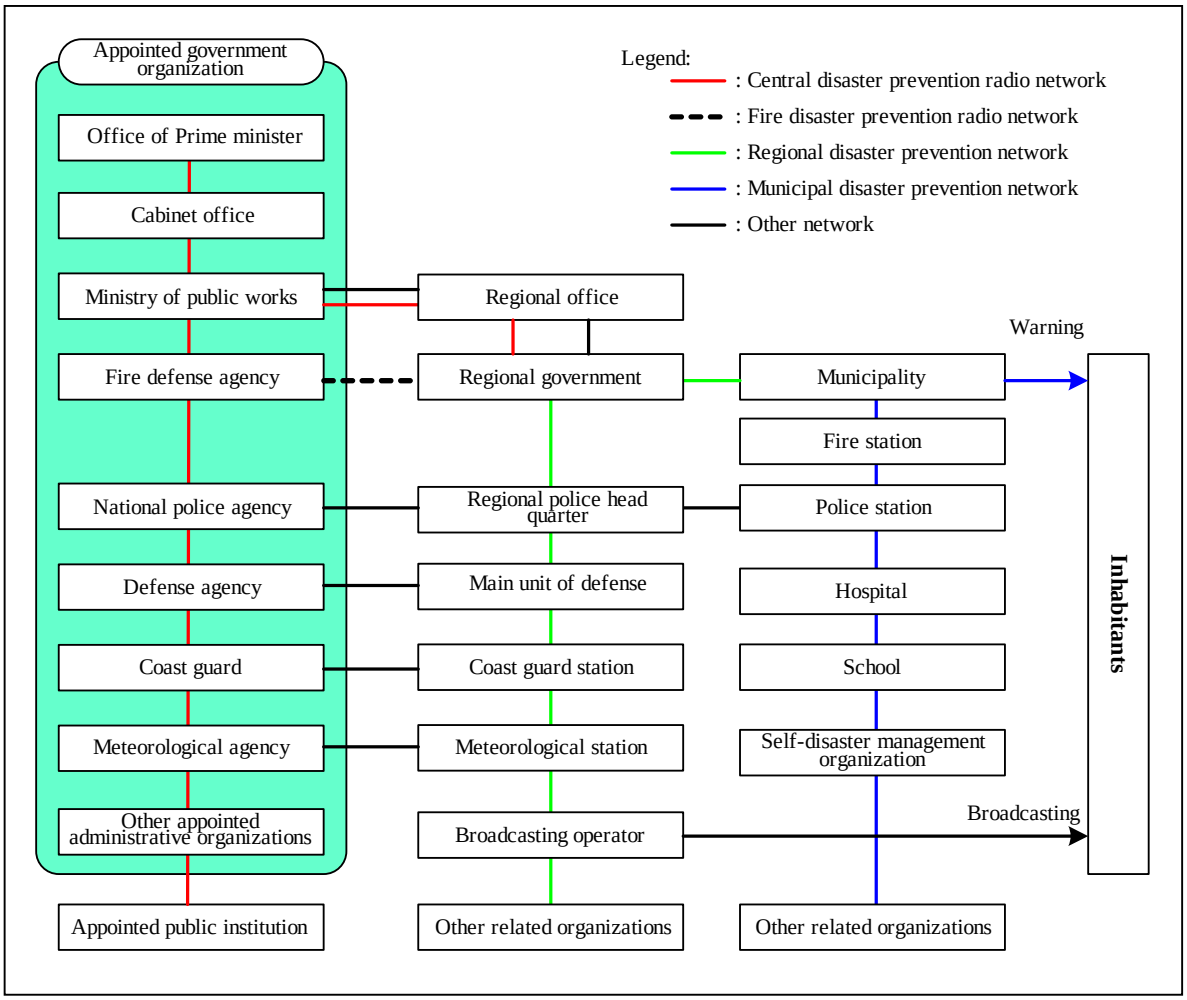


Figure 9. 4 Disaster Prevention Organization and Network Structure in Japan

9.4.4 Disaster Mitigation Information Flow in Japan

A comprehensive disaster prevention organization is not yet established in the Maldives, as above-mentioned. In Japan, there are three phases in disaster prevention:

1) Prevention,
2) Disaster emergency measures, and
3) Disaster recovery.

The above process leads to mitigation of damage because the persons concerned take the best measures in each phase. In addition to the above, disaster prevention needs to be implemented integrally and systematically with the cooperation of the national government, regional government, public institutions, and residents.

In Japan, disaster emergency measures are classified into three stages:

1) transmission of warnings in before the disaster,

2) finding the situation immediately after disaster, and

3) emergency recovery, with the cooperation of all related parties.

The typical flow of information during disaster emergency measures in Japan is shown in Figures. 9.6 to 9.8 bellow:

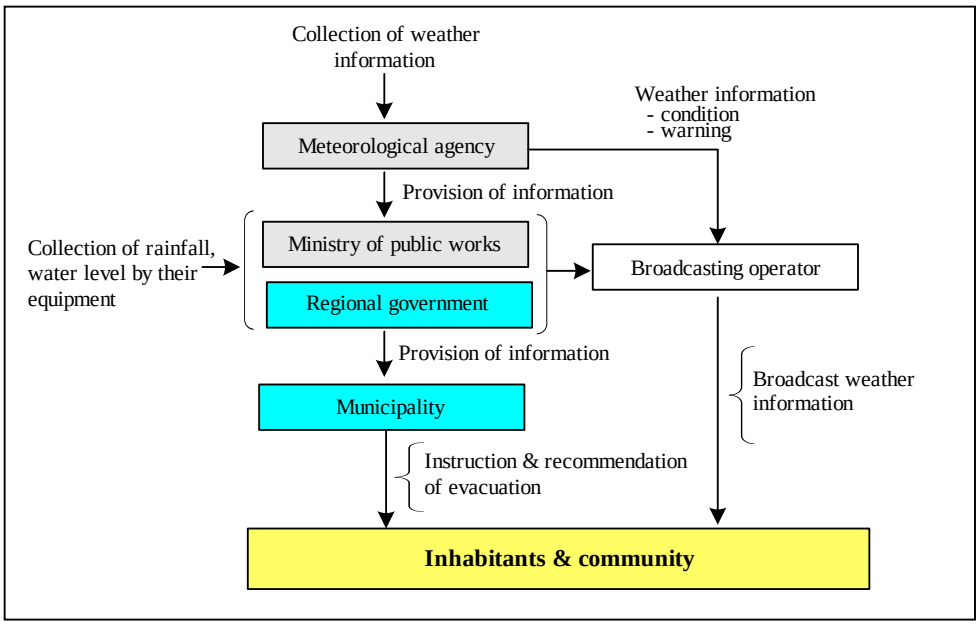


Figure 9. 4 Transmission of Warning

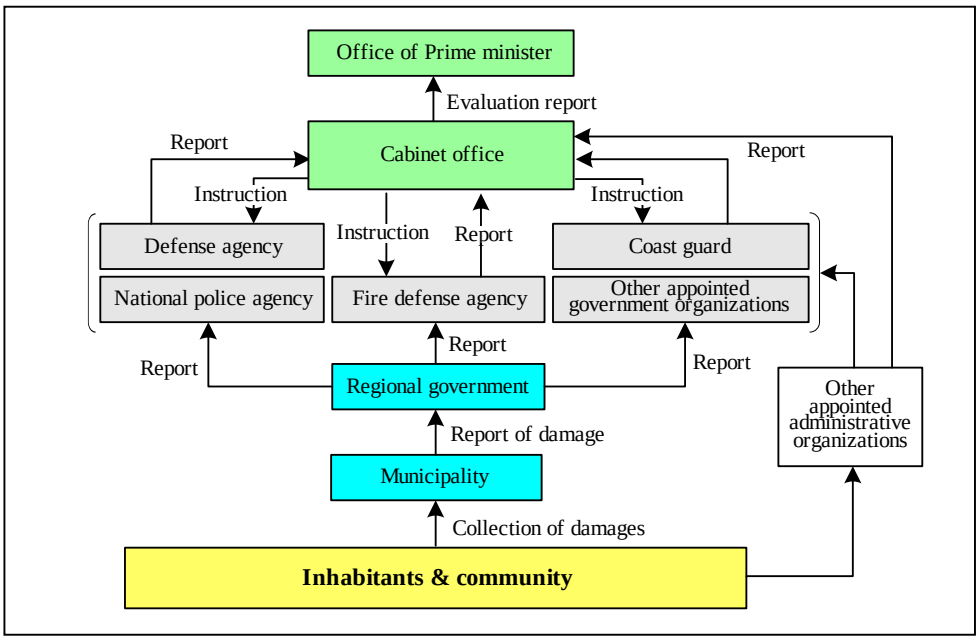


Figure 9. 4 Finding the Condition Immediately after a Disaster

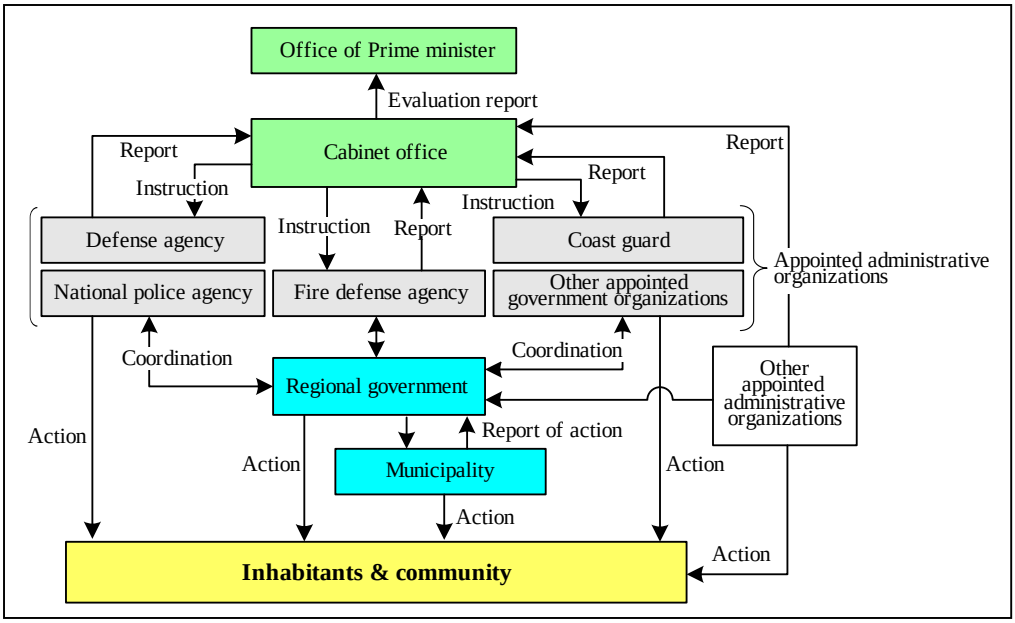


Figure 9. 4 Emergency Recovery

9.4.5 Recommendation for a Disaster Prevention Plan in the Maldives

It is recommended that the Maldives set up a Disaster Prevention Plan. The Maldives plan could be based on the Japanese plan, as this has been found to be very appropriate in Japan.

The target organization and information flow for a Disaster Prevention Plan in the Maldives needs to be established. As a first step, in order to functionalize alternative communications and network systems, it is desirable for the following organizations to participate in a system. This suggestion is based on the experiences in Japan, and on the current situation of the Maldives:

1) Department of Meteorology (DOM)
2) National Disaster Management Center (NDMC)
3) Ministry of Atolls Development (MOAD)
4) Island Offices including Police Stations
5) Telecommunication Authority of Maldives (TAM)

Procedures for issuing warning announcements, and other major functions of the organizations mentioned above, could be considered as follows:

Table 9. 5 Major Function of Related Organizations

	Organization	Major function
1)	DOM	• Collection and distribution of tsunami and weather information.
2)	NDMC	• Forecasting the potential disaster range. • Coordination with related national government organizations. • Formulating plans for disaster and emergency countermeasures and recovery work.
3)	MOAD	• Issuing instructions and recommendations for evacuation. • Coordination with related regional government organizations. • Preparation of condition and progress reporting of disaster emergency countermeasures and recovery work.
4)	Atoll Offices	• Transmission of instructions and recommendations for evacuation to the Island offices. • Collection of information of emergency countermeasure and recovery operations in their administrative area. • Execution of emergency countermeasure and recovery work.
5)	Island offices including Police station	• Transmission of instructions and recommendation for evacuation to residents. • Collection of information on emergency countermeasures and recovery conditions in their administrative area. • Execution of emergency countermeasure and recovery works.
6)	Telecommunication Authority of Maldives	• Maintain alternative communications and network systems and ensure that they kept in good condition. • Priority operation of the public communication equipment in case of an emergency.

The DOM will deal with the collection of tsunami and weather information from the Indian Ocean Tsunami Warning Center and reception of weather information. The Department will also distribute this information within the Maldives. In addition to this, the DOM will provide the mass media (mainly radio and television stations) with primary information, such as a current weather bulletins.

Based on tsunami information and a weather bulletins, the NDMC will evaluate the situation and determine the possibility of a disaster occurring. The NDMC will inform the MOAD of the result of their evaluation.

The MOAD will issue recommendations for evacuation via the Atoll Offices to the Island Offices which have the possibility of being affected by a disaster.

The Atoll Offices will inform the potentially affected Island Offices, and the Island Office will announce warnings to residents.

Potential information flows during the disaster emergency countermeasure phase are presented in Figures. 3-9 to 3-11 bellow:

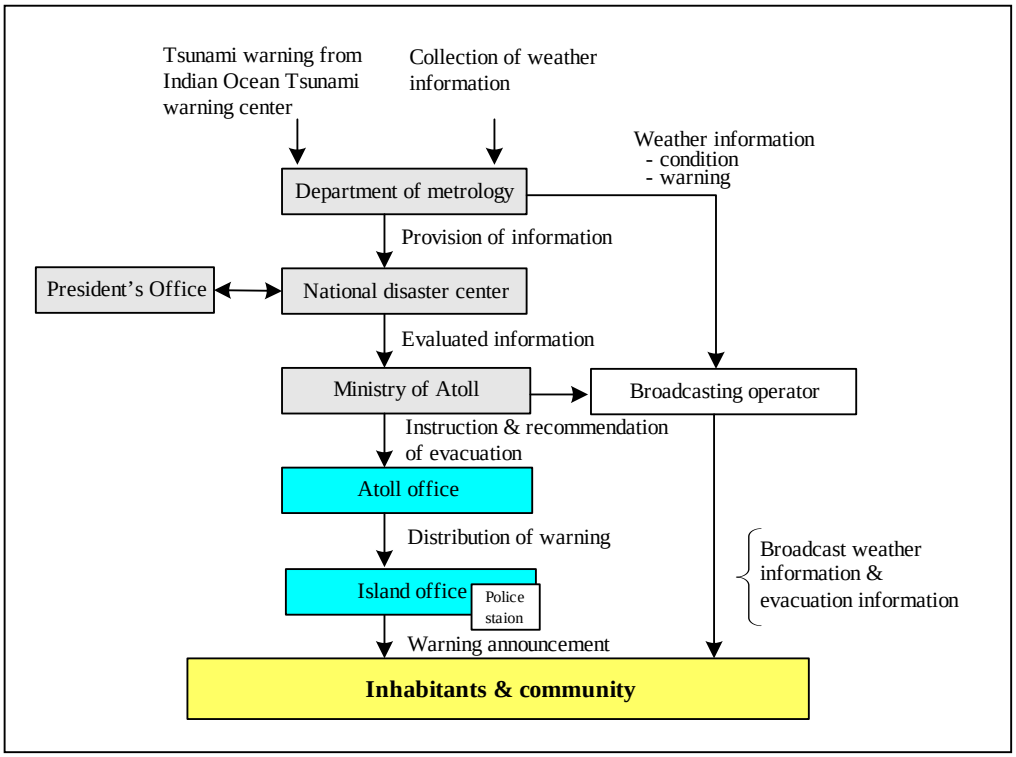


Figure 9. 4 Potential Flow of Information for Emergency Warnings

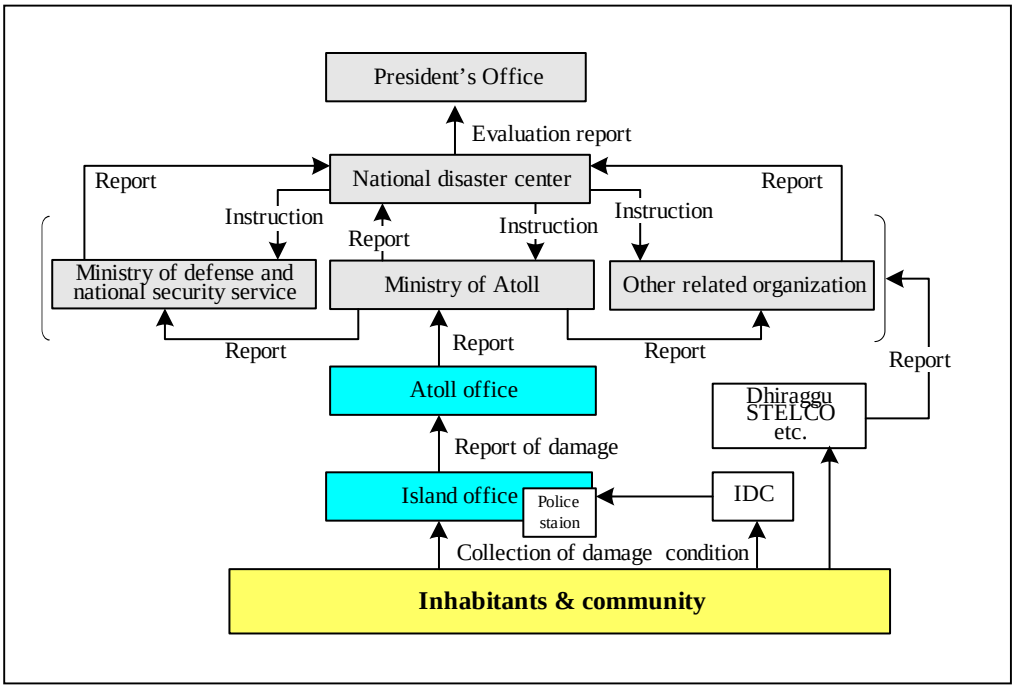


Figure 9. 4 Potential Flow of Information for Assessments Immediately after a Disaster

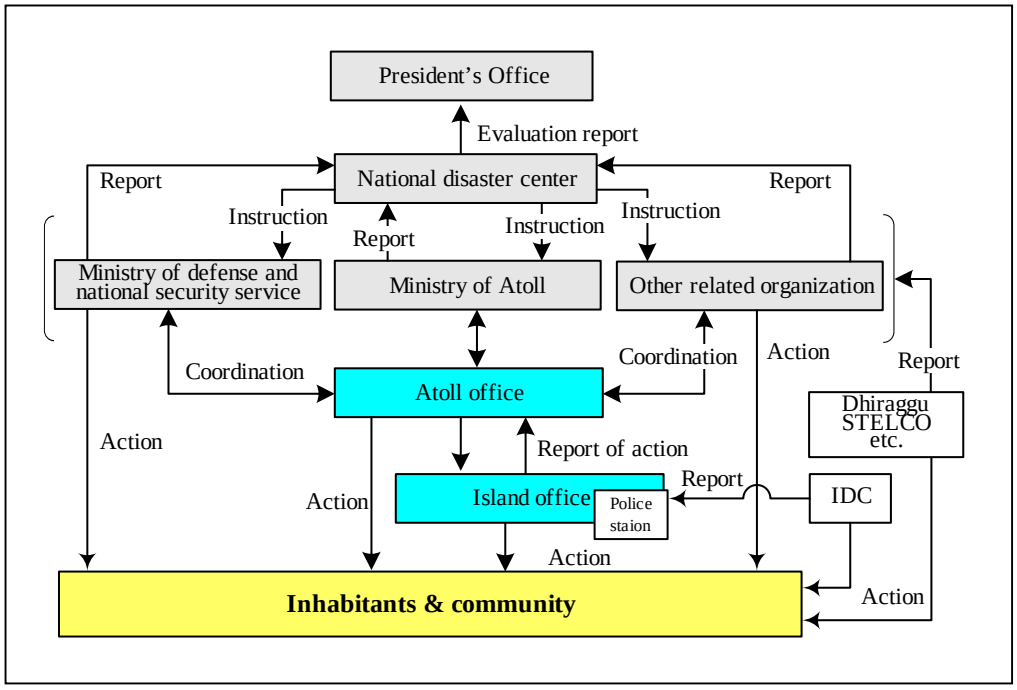


Figure 9. 4 Potential Flow of Emergency Recovery

9.4.6 Preliminary Radio Circuit Desk Top Design

In order to specify system performance requirements, a preliminary radio circuit desk top design was carried out in this study. In this design, the following maters were considered:

1) Daily and annual variations in the stability of Digital HF radio communications.
2) Communication conditions for both a VHF early warning system and a VHF trunked line system:
   - ✓ Permissible transmission loss, and
   - ✓ Available transmission distance and antenna height in relation to the quality of communications (S/N: Signal to Noise ratio).

It is noted that this radio circuit is a desk top design that was prepared to clarify the system outline. Therefore, the designed system needs to undergo radio wave propagation testing in the detailed design stage.

(1) General Condition and Summary of Results

Table 3.3 below shows the general condition and result of the circuit design analysis.

Table 9. 6 General Condition and Summary of the Result

Radio Transmission Span		Distance	Frequency Band	Output Power	Antenna Height	Antenna Type & Gain	Permissible Transmission Loss	Circuit Margin	Judgment
(1)	**Digital HF Radio System**								
	• Male'-Fonadhoo	290km	3MHz – 30MHz	125kW	N.A.	Dipole : 3 – 5dBi Dipole : 0dBi	Refer to bellow	N.A.	OK, but 3 bands are preferred
	• Male'-Hithadhoo	500km	3MHz – 30MHz	125kW	N.A.	Dipole : 3 – 5dBi Dipole : 0dBi	Refer to bellow	N.A.	OK, but 3 band are preferred
(2)	**VHF Early Warning System**								
	• Fonadhoo-Ishidhoo	32.7km	60MHz band	10W	40m	Sleeve : 2.2dBi 3-ele Yagi : 8.2dBi	128.7dB	6.1dB	OK
	• Fonadhoo-Maabaidhoo	22.0km	60MHz band	10W	40m	Sleeve : 2.2dBi 3-ele Yagi : 8.2dBi	128.7dB	14.0dB	OK
	• Fonadhoo-Gan	10.3km	60MHz band	10W	40m	Sleeve : 2.2dBi 3-ele Yagi : 8.2dBi	128.7dB	28.4dB	OK
	• Fonadhoo-Maavah	29.3km	60MHz band	10W	40m	Sleeve : 2.2dBi 3-ele Yagi : 8.2dBi	128.7dB	8.3dB	OK
(3)	**VHF Trunked Line System**								
	• Fonadhoo-Ishidhoo	32.7km	150MHz band	10W	40m	3-stage collinear :6dBi 3-stage collinear :6dBi	132.5dB	3.2dB	OK
	• Fonadhoo-Maabaidhoo	22.0km	150MHz band	10W	40m	3-stage collinear :6dBi 3-stage collinear :6dBi	132.5dB	13.3dB	OK
	• Fonadhoo-Gan	10.3km	150MHz band	10W	40m	3-stage collinear :6dBi 3-stage collinear :6dBi	132.5dB	30.0dB	OK
	• Fonadhoo-Maavah	29.3km	150MHz band	10W	40m	3-stage collinear :6dBi 3-stage collinear :6dBi	132.5dB	6.2dB	OK

NOTES: N.A.: Not Applicable

(1) Daily and Annual Communication Stability of Digital HF Radios

In addition to the above, study was performed by following conditions.

- Sun spot number (SSN): 10, 60, 100
- Calculated month: Jan, Apr, Jul, Oct.

It is common to make a judgment value of 45dB or more for voice communication and 55dB or more for data communication in the preliminary design stage. As a result of the calculations, it was determined that in order to secure a stable radio circuit throughout the day and year, it is desirable to secure three (3) HF radio channels respectively for each frequency band (3MHz, 7 MHz, and 10 MHz). The worst case for each SSN class is shown below and other results are attached in the Appendix.

(1) Male'-Fonadhoo (SSN:10)

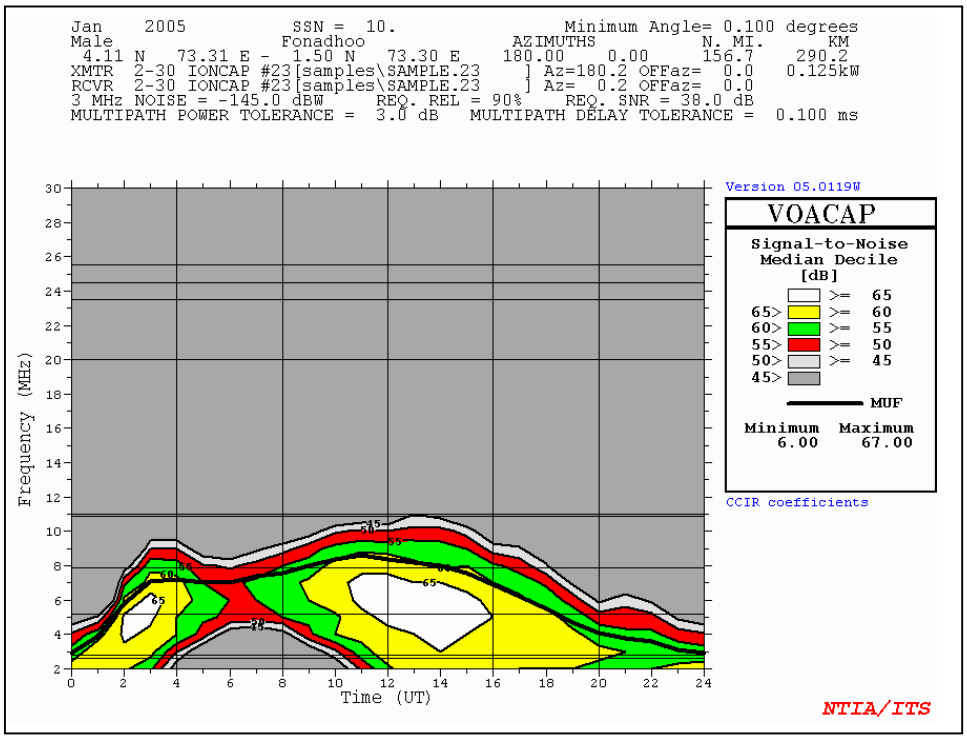


Figure 9. 4 HF Radio Propagation Model (Jan, SSN:10)

(2) Male'-Fonadhoo (SSN:60)

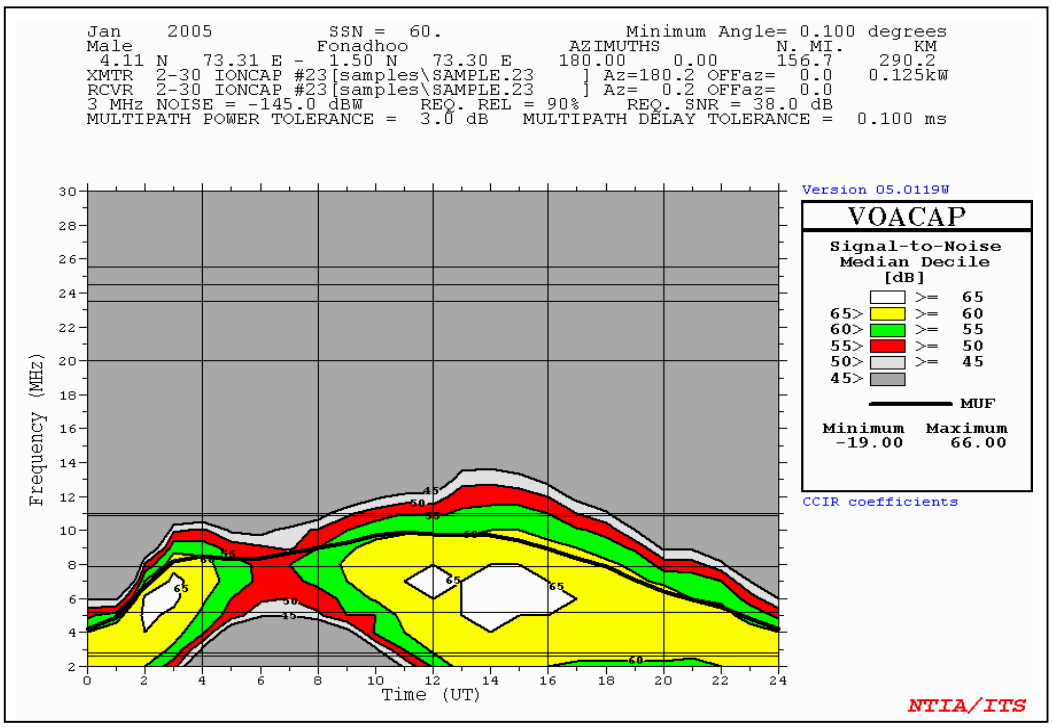


Figure 9. 4 HF Radio Propagation Model (Jan, SNN:60)

(3) Male'-Fonadhoo (SSN:100)

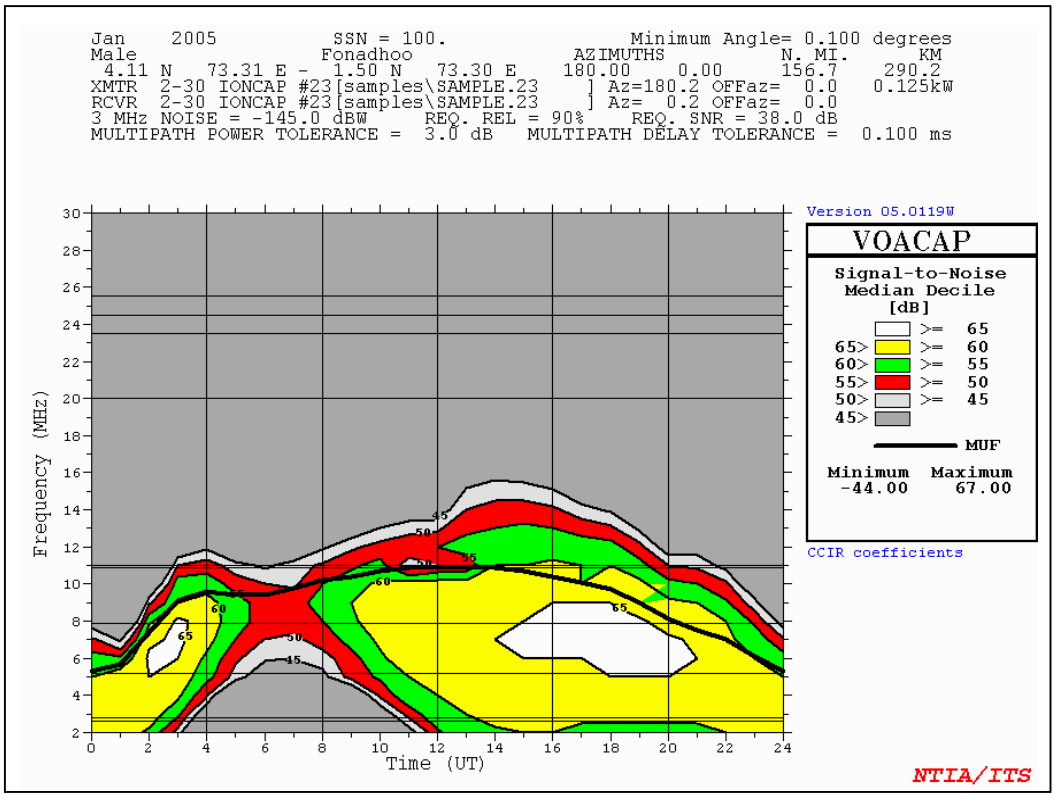


Figure 9. 4 HF radio Propagation Model (Jan, SNN:100)

(4) Male'- Hithadhoo (SSN:10)

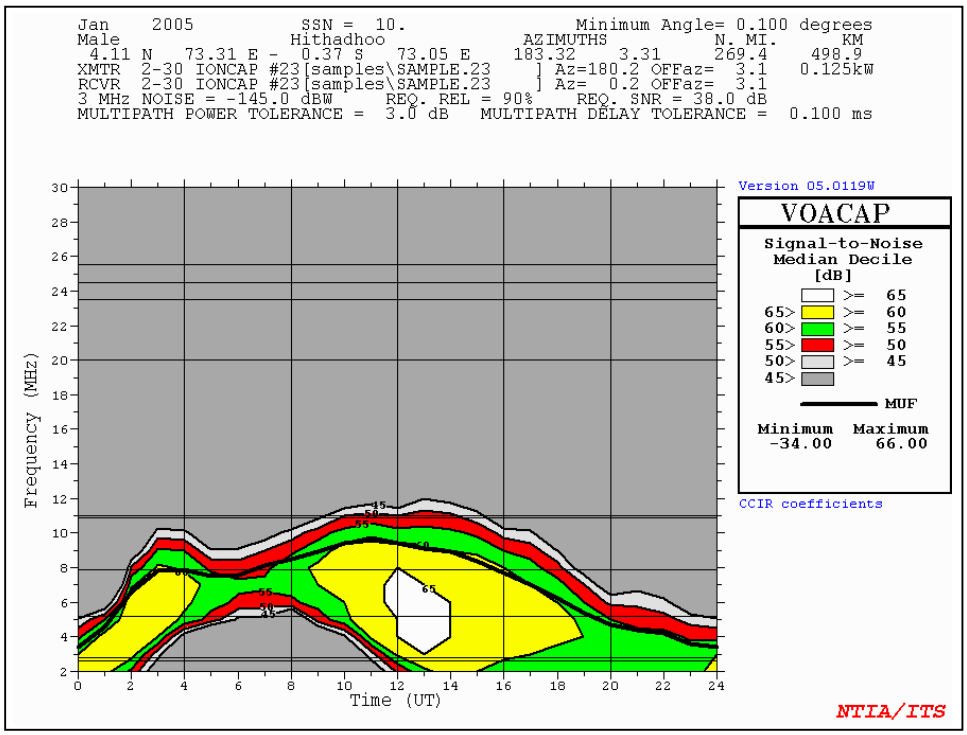


Figure 9. 4 HF Radio Propagation Model (Jan, SNN:10)

(5) Male'- Hithadhoo (SSN:60)

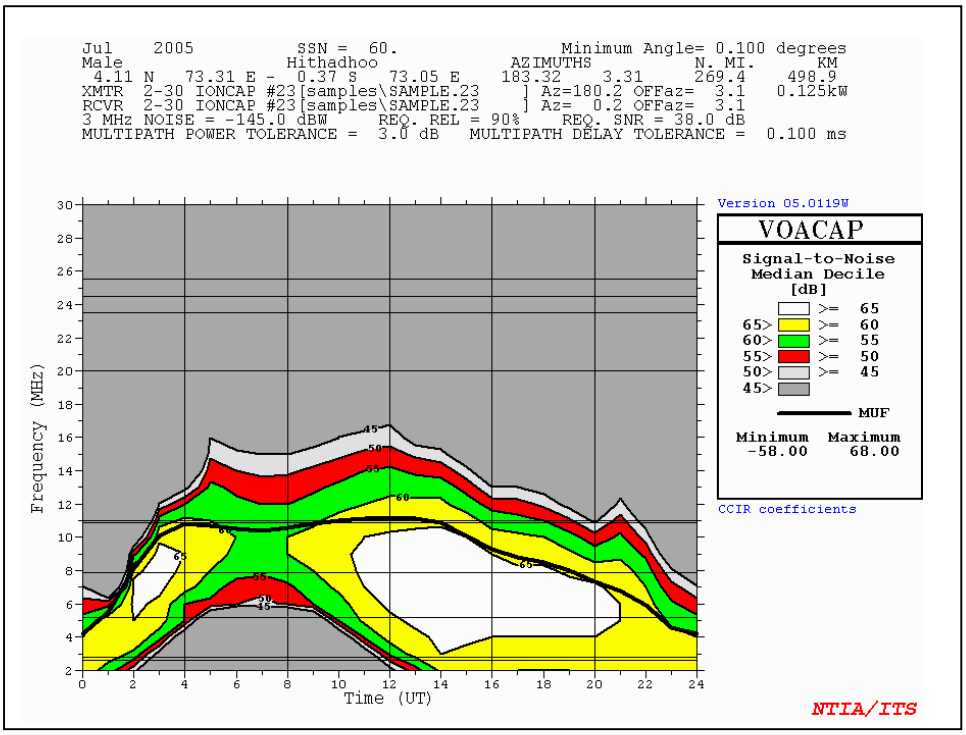


Figure 9. 4 HF Radio Propagation Model (Jul, SNN:60)

(6) Male'- Hithadhoo (SSN:100)

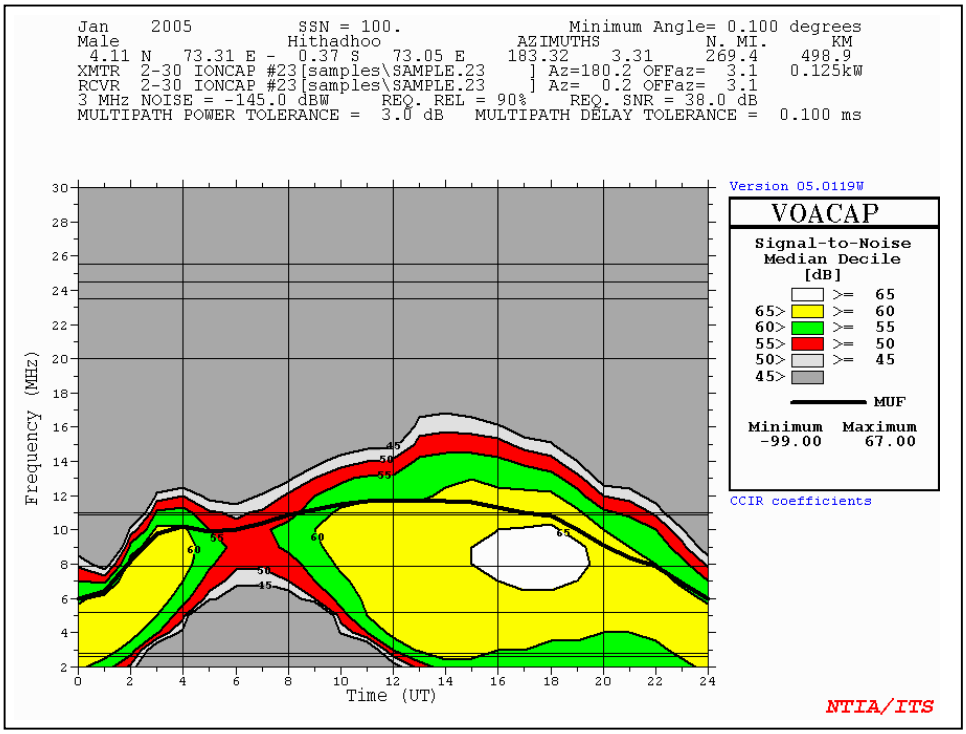


Figure 9. 4 HF Radio Propagation Model (Jan, SNN:100)

(2) VHF Early Warning System and VHF Trunked Line System

In accordance with standards applying to regional simultaneous communication systems in Japan, the technical standard for telemetering and warning systems used by the Ministry of Land Infrastructure and Communication Japan and technical standards of the Ministry of Internal Affairs and Communications Japan, the permissible transmission loss, available transmission distance and antenna height were studied.

Permissible transmission loss is calculated from conditions of the transmitter and receiver, receiver characteristics, earth conditions, interference fading and reflection loss by ocean, etc. On the other hands, available transmission distance and antenna height are calculated as follows:

$$\text{Available transmission distance and antenna height} = \text{Circuit margin} \geqq 0$$

$$\text{Circuit margin} = \text{Permissible transmission loss} - \text{Free space loss} - \text{Plane ground loss} - \text{Fading loss}$$

(1) Permissible Transmission Loss and Transmission Characteristics for VHF Early Warning System

i) Condition of Transmitter and Receiver

Item	Calculated value	Frequency	Output power	Antenna		Antenna height	Antenna feeder loss			Other loss	
				Type	Gain		Type	Length	Attenuation	Name	Loss
Condition of Transmitter	39.8dBm	60.0MHz	10.0W 40.0dBm	Sleeve	2.2dBi	40.0m	10D (0.038dB/m)	50.0m	1.9dB	Arrester	0.5dB
Condition of Receiver	5.8dB			3ele-Yagi	8.2dBi	40.0m	10D (0.038dB/m)	50.0m	1.9dB	Arrester	0.5dB

ii) Receiver Characteristics

Item	Calculated value	Bandwidth	Noise figure	External noise	Frequency deviation	Transmitter characteristics	Receiver characteristics	Receiving power	Receiving noise power	Radio frequency S/N	S/N improvement coefficient
Internal noise	-125.2dBm	12.0kHz	8.0dB								
Receiver noise	-120.1dBμV			-121.7dBm							
S/N improvement coefficient	9.1dB	12.0kHz			3.5kHz						
Receiving power	45.6dBm					39.8dBm	5.8dB				
Radio frequency S/N	165.7dBm							45.5dBm	-120.1dBm		
Standard S/N	174.8dBm									165.6dB	9.1dB

iii) Permissible Transmission Loss

Permissible transmission loss	Standard S/N	Criteria S/N	Earth condition	Interference fading	Reflection loss by ocean
128.8dB	174.8dB	30.0dB	10.0dB	3.0dB	3.0dB

iv) Transmission Characteristics

Distance	km	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5	50.0
Free space loss	dB	81.9	85.5	88.0	89.9	91.5	92.8	94.0	95.0	95.9	96.7	97.5	98.2	98.8	99.4	100.0	100.5	101.0	101.5	101.9
Plane ground loss	dB	1.9	5.4	7.9	9.9	11.4	12.8	13.9	15.0	15.9	16.7	17.5	18.2	18.8	19.4	20.0	20.5	21.0	21.4	21.9
Fading loss	dB	3.5	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.3	6.5	6.8	7.0	7.3	7.5	7.8	8.0
Total loss	dB	87.3	94.6	99.9	104.0	107.4	110.3	112.9	115.2	117.3	119.2	121.0	122.6	124.1	125.6	127.0	128.3	129.5	130.7	131.8
Circuit margin	dB	41.5	34.2	28.9	24.8	21.4	18.4	15.9	13.6	11.5	9.6	7.8	6.2	4.7	3.2	1.8	0.5	-0.7	-1.9	-3.0

9-29

(2) Permissible transmission loss and transmission characteristics for VHF Trunked Line System

i) Condition of Transmitter and Receiver

Item	Calculated value	Frequency	Output power	Antenna		Antenna height	Antenna feeder loss			Other loss		Remarks
				Type	Gain		Type	Length	Attenuation	Name	Loss	
Condition of Transmitter	155.3dBμV	150.0MHz	10.0W 153.0dBμV	3stage-collinear	6.0dBi	40.0m	10D (0.064dB/m)	50.0m	3.2dB	Arrester	0.5dB	Diversity gain
Condition of Receiver	5.3dB			3stage-collinear	6.0dBi	40.0m	10D (0.064dB/m)	50.0m	3.2dB	Arrester	0.5dB	3.0dB

ii) Receiver Characteristics

Item	Calculated value	Standard C/N	Maintenance margin	C/I margin	Bandwidth	Noise figure	External noise	Code gain
Required C/N	21.1dB	12.1dB	6.0dB	3.0dB				
Thermal noise	-122.0dBm				25.0kHz	8.0dB		
Total Noise	-4.0dBμV						-119.0dBm	
Required receiver input voltage	12.1dBμV							5.0dB

iii) Permissible Transmission Loss

Permissible transmission loss	Condition of transmitter	Condition of receiver	Required receiver input voltage	Earth condition	Interference fading	Reflection loss by ocean
132.5dB	155.3dB	5.3dB	12.1dB	10.0dB	3.0dB	3.0dB

iv) Transmission Characteristics

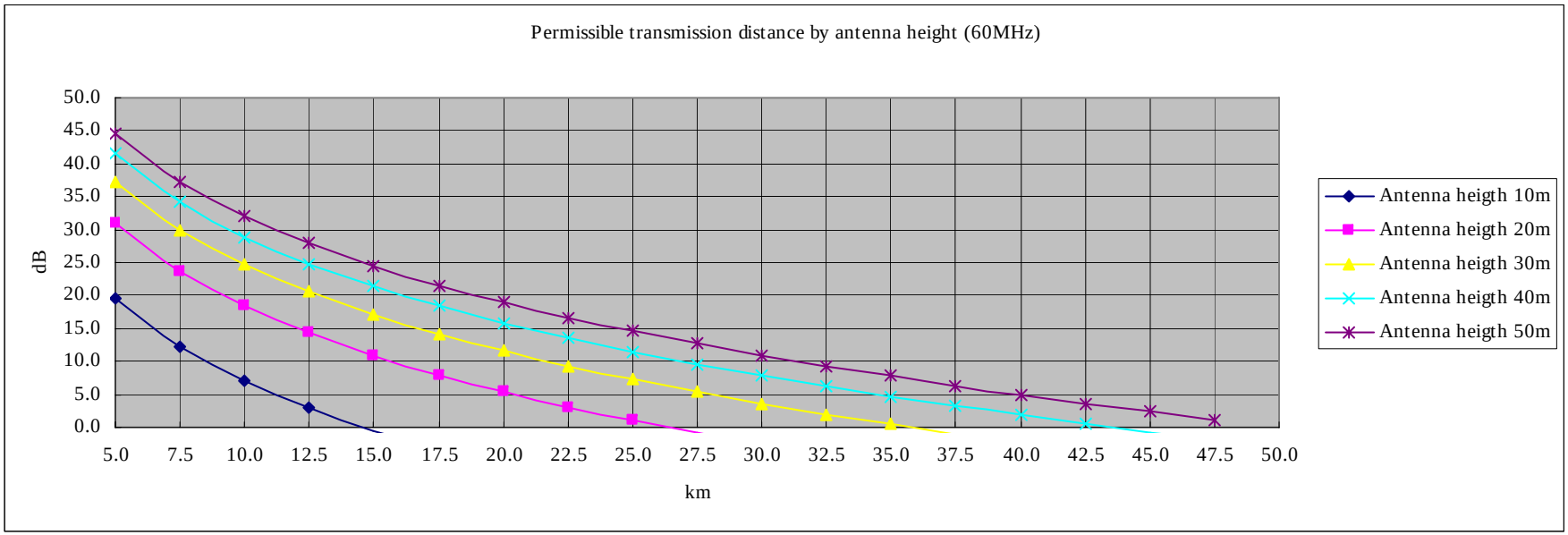
Distance	km	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5
Free space loss	dB	89.9	93.4	95.9	97.9	99.4	100.8	101.9	103.0	103.9	104.7	105.5	106.2	106.8	107.4	108.0	108.5	109.0	109.5
Plane ground loss	dB	0.0	0.0	0.0	1.9	3.5	4.8	6.0	7.0	7.9	8.7	9.5	10.2	10.8	11.4	12.0	12.5	13.0	13.5
Fading loss	dB	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.8	16.5	17.3
Total loss	dB	94.4	98.7	101.9	106.5	110.4	113.8	116.9	119.7	122.3	124.7	127.0	129.1	131.1	133.1	135.0	136.8	138.5	140.2
Circuit margin	dB	38.1	33.8	30.6	26.0	22.1	18.7	15.6	12.8	10.2	7.8	5.5	3.4	1.4	-0.6	-2.5	-4.3	-6.0	-7.7

9-30

(3) Available Transmission Distance and Antenna Height in Relation to the Quality of Communication (S/N: Signal to Nose ratio)

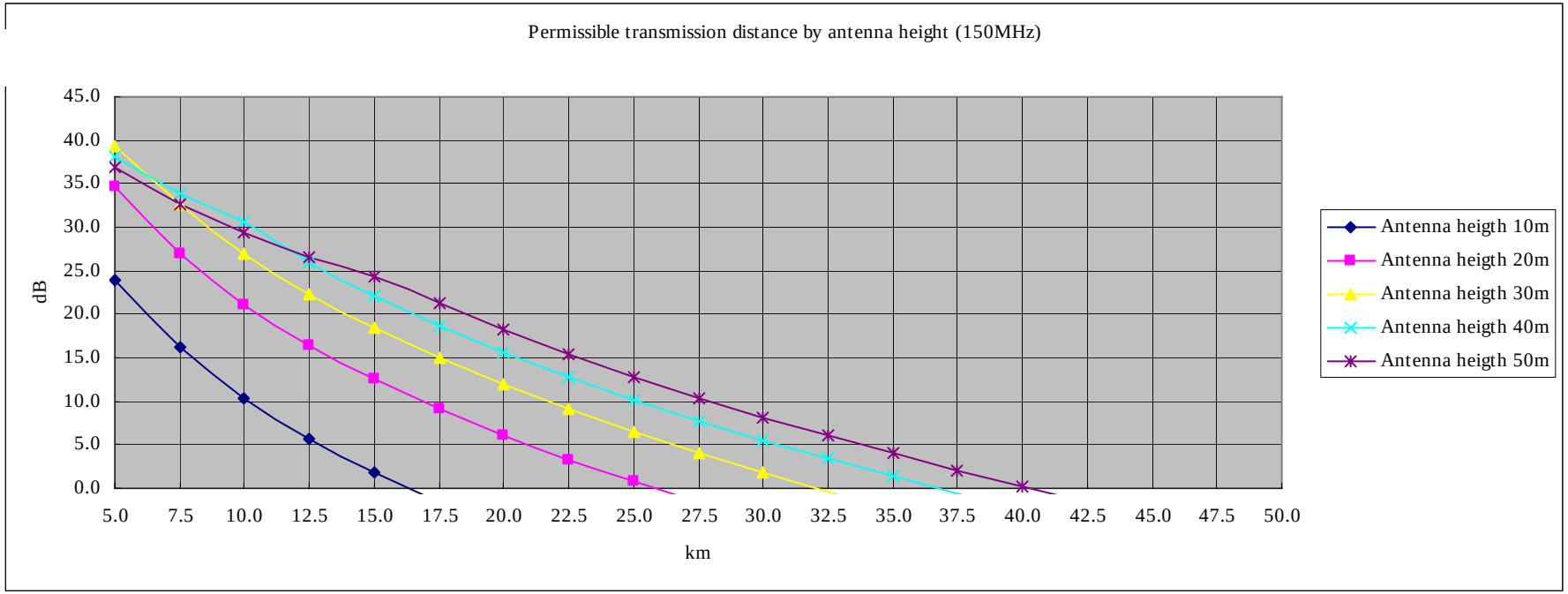
i) VHF Early Warning System

Item		Circuit Margin																	
Antenna height	10m	19.7	12.4	7.1	3.0	-0.4	-3.4	-5.9	-8.2	-10.3	-12.2	-14.0	-15.6	-17.1	-18.6	-20.0	-21.3	-22.5	-23.7
Antenna height	20m	30.9	23.6	18.4	14.3	10.9	7.9	5.4	3.1	1.0	-0.9	-2.7	-4.3	-5.9	-7.3	-8.7	-10.0	-11.2	-12.4
Antenna height	30m	37.2	29.9	24.7	20.6	17.1	14.2	11.6	9.3	7.3	5.4	3.6	2.0	0.4	-1.0	-2.4	-3.7	-4.9	-6.1
Antenna height	40m	41.5	34.2	28.9	24.8	21.4	18.4	15.9	13.6	11.5	9.6	7.8	6.2	4.7	3.2	1.8	0.5	-0.7	-1.9
Antenna height	50m	44.6	37.3	32.0	27.9	24.5	21.6	19.0	16.7	14.6	12.7	11.0	9.3	7.8	6.3	5.0	3.6	2.4	1.2
Distance	km	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5



ii) VHF Trunked Line System

Item		Circuit Margin																	
Antenna height	10m	23.9	16.1	10.4	5.8	1.8	-1.6	-4.7	-7.5	-10.0	-12.4	-14.7	-16.8	-18.9	-20.8	-22.7	-24.5	-26.2	-27.9
Antenna height	20m	34.7	26.9	21.1	16.5	12.6	9.2	6.1	3.3	0.7	-1.7	-3.9	-6.1	-8.1	-10.1	-11.9	-13.7	-15.5	-17.2
Antenna height	30m	39.4	32.7	26.9	22.3	18.4	14.9	11.9	9.1	6.5	4.1	1.8	-0.3	-2.4	-4.3	-6.2	-8.0	-9.7	-11.4
Antenna height	40m	38.1	33.8	30.6	26.0	22.1	18.7	15.6	12.8	10.2	7.8	5.5	3.4	1.4	-0.6	-2.5	-4.3	-6.0	-7.7
Antenna height	50m	36.8	32.5	29.3	26.6	24.3	21.2	18.2	15.4	12.8	10.4	8.1	6.0	4.0	2.0	0.1	-1.7	-3.4	-5.1
Distance	km	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5



9-32

9.4.7 System Configurations and Functions

(1) System configurations

After completing the desk top design, an overall conceptual system configuration was drawn up. Figure 9.18 below illustrates this system outlook whereas the major components of each system are shown in Table 9.7 below.

Table 9. 7 Major item of each system

	Item	Male	Atoll office	Island office
1.	**Digital HF radio system**			
1)	125W transmitter and receiver	o	o	
2)	Antenna system	o	o	
3)	Software for data communication	o	o	
4)	Printer & FAX	o	o	
5)	Personal computer	o	o	
6)	Isolation transformer	o	o	
7)	AC power supply and UPS	o	o	
2.	**VHF trunked line system**			
1)	Base radio station system		o	
	• 10W radio system with antenna		o	
	• Node, network and dispatcher control system		o	
2)	Fixed radio station system			o
	• 10W radio system with antenna			o
	• Printer & FAX			o
	• Message terminal			o
3)	Portable radio terminal		o	o
4)	AC power supply and UPS		o	o
3.	**VHF early warning system**			
1)	Master station system		o	
	• 10W transmitter and receiver		o	
	• Control equipment		o	
	• Antenna & Arrester		o	
	• AC power supply and UPS		o	
2)	Speaker warning station system			
	• 10W transmitter and receiver			o
	• Remote controller			o
	• Antenna system			o
	• Loud speaker (30W)			o
	• AC power supply and UPS			o
4.	**Multiplex radio system**			
1)	8.2GHz digital multiplex radio system	o		
2)	Antenna system	o		
3)	Isolation transformer	o		
4)	AC power supply and UPS	o		
4.	**Antenna tower**			
1)	Antenna tower for Multiplex radio	o		
2)	Antenna tower for VHF system		o	o
3)	Antenna tower for Digital HF System	o	o	

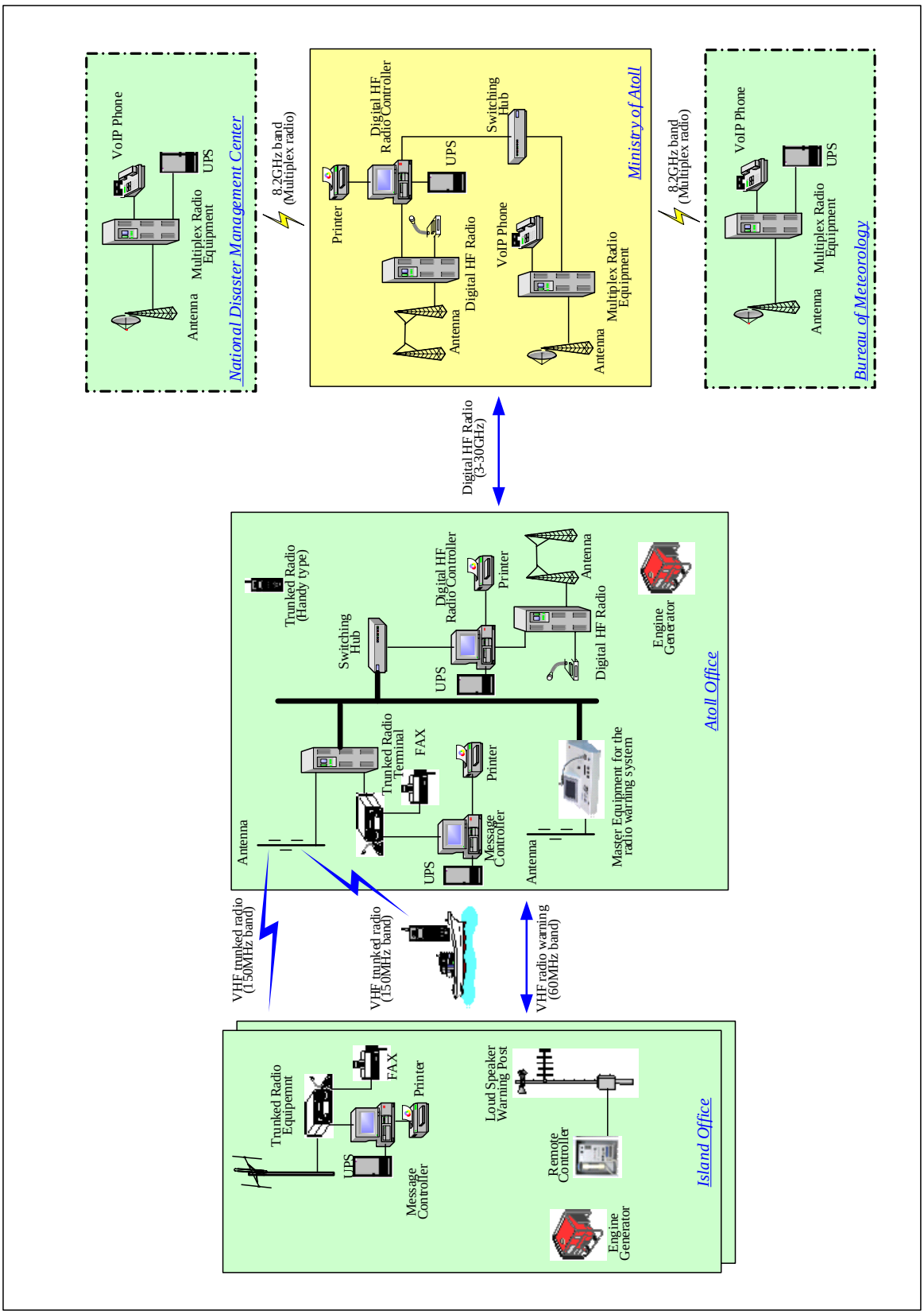


Figure 9. 5 Conceptual System Diagram

(2) System functions

(1) Basic functions

i) Voice communications

- ✓ Voice communication between the MOAD office and the atoll offices using the digital HF radio system. In addition, voice communication via analogue HF radio devices using single side band (SSB) modulation.
- ✓ The trunked line system is used for voice communication between an atoll office and its island offices. The trunked line system at island offices can also communicate with the existing VHF radio devices.
- ✓ All-out (atoll-wide), individual, group and prioritized communication modes from an atoll office to its island offices.
- ✓ Communication between portable radio terminals and an atoll office or island offices.
- ✓ Voice communication (VoIP) between the MOAD and the DOM or the NDMC via the multiplex radio system.

ii) Message transfer

- ✓ Message exchange between the MOAD and the atoll offices using digital HF radio system terminals.
- ✓ Message exchange between the MOAD and the DOM, and between the MOAD and the NDMC using multiplex radio system terminals.
- ✓ The MOAD can send emergency messages by selecting preset warnings or other messages stored in the system terminal. The selected message will be transferred to the atoll office, where it will automatically boot up the VHF early warning system and thereby broadcast the message through the loud speakers installed in individual Island offices. Concurrently, the transferred message can be displayed on and printed out from the message terminals of the trunked line system installed in each island office.
- ✓ Messages can be exchanged between an atoll office and its Island offices through the message terminals of the trunked line system.
- ✓ Facsimile transmission between the MOAD and the atoll offices or island offices using a facsimile machine which can be connected to the digital HF radio system.
- ✓ Facsimile transmission between an atoll office and its island offices by adding a facsimile machine to the trunked line radio system.

iii) Voice Announcements

- ✓ Voice announcements from the microphone at an atoll office to the loud speakers installed in its island offices via the Early Warning System. In addition to sending warnings, other messages, chimes, music, etc. can also be broadcast.
- ✓ An atoll office can select from atoll-wide all-out, emergency all-out, individual and group broadcasting modes.
- ✓ Emergency messages, including tsunami warnings, will be broadcast automatically in the emergency all-out mode.

- ✓ The island offices can announce voice message by using a remote controller with a microphone.

iv) MOAD

- ✓ The MOAD can select and send emergency messages, including tsunami warnings. In addition, the MOAD can activate loud speakers in island offices to announce evacuation messages (in the all-out, group or individual mode).
- ✓ Message exchange with the atoll offices.
- ✓ Voice communication with the atoll offices.
- ✓ Facsimile transmission with the atoll offices and the island offices.
- ✓ Voice communication (VoIP) and facsimile transmission with the DOM and the NDMC.

v) DOM

- ✓ Voice communication (VoIP) and facsimile transmission with the MOAD and the NDMC.

vi) NDMC

- ✓ Voice communication (VoIP) and facsimile transmission with the MOAD and the DOM.

vii) Atoll offices

- ✓ Voice communication and facsimile transmission with the MOAD and the other atoll offices.
- ✓ Voice communication with various other general analogue HF radio stations.
- ✓ Voice communication with the island offices (in the all-out, group or individual mode).
- ✓ Voice communication with existing VHF radio devices.
- ✓ Voice communication with portable radio terminals.
- ✓ Message exchange with the Island offices.
- ✓ Facsimile transmission between the island offices.
- ✓ Voice announcement from the microphone to loud speakers installed in the island offices. In addition to broadcasting preset warnings, other messages, chimes and music, etc. will also be able to be broadcast.
- ✓ Automated voice announcement of emergency messages, including tsunami warnings, through the loud speaker system installed at the island offices.

viii) Island Offices

- ✓ Voice communication with the atoll office and the other island offices.
- ✓ Message exchange with the MOAD, the atoll office and the other island offices.
- ✓ Facsimile transmission between the MOAD, the atoll office and the other island offices.
- ✓ Voice communication with potable radio terminals.
- ✓ Voice announcement through loud speakers using a remote controller.
- ✓ Voice communication with existing VHF radio devices.

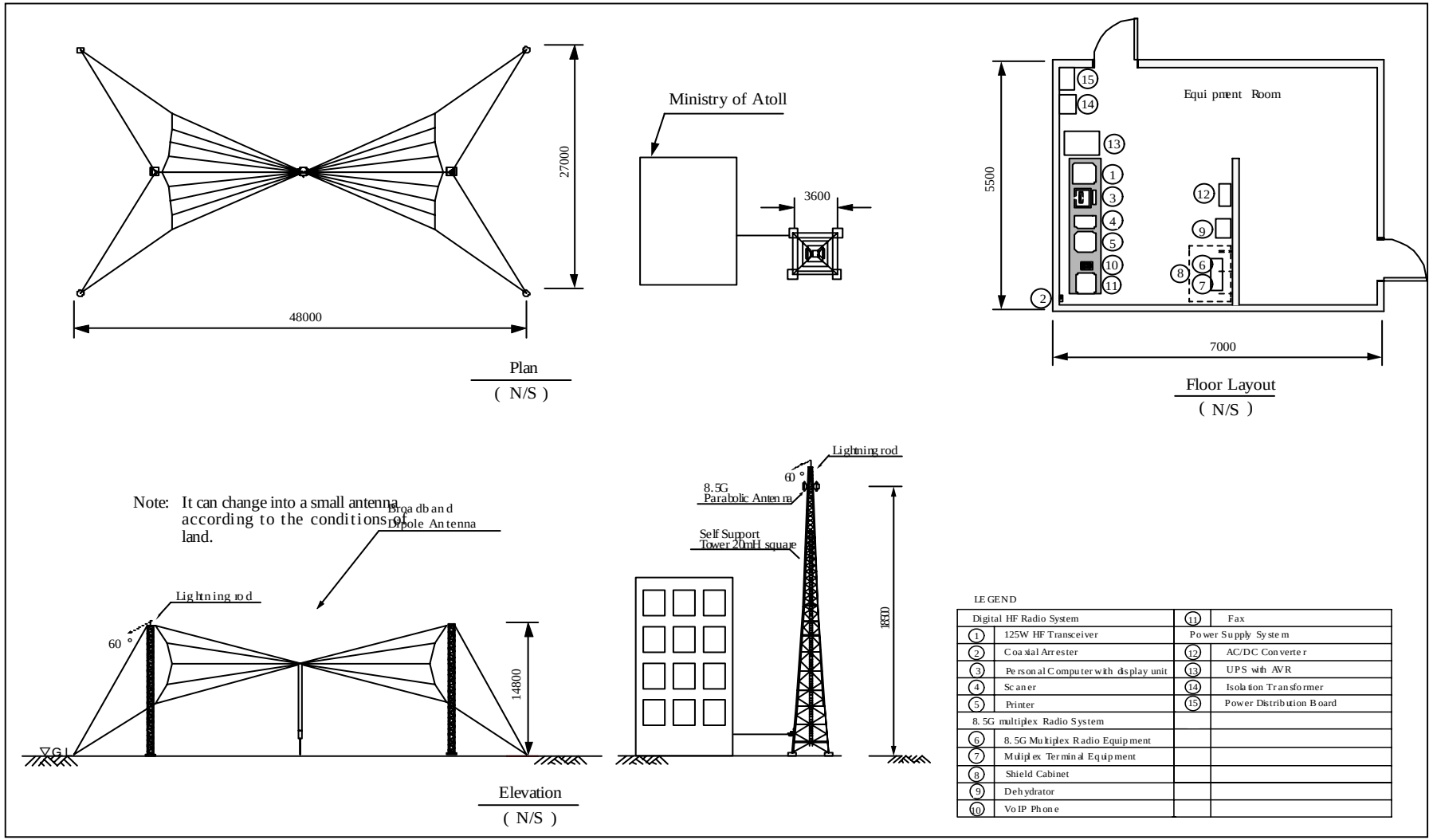


Figure 9. 5 Example of Typical Facility Layout (Male')

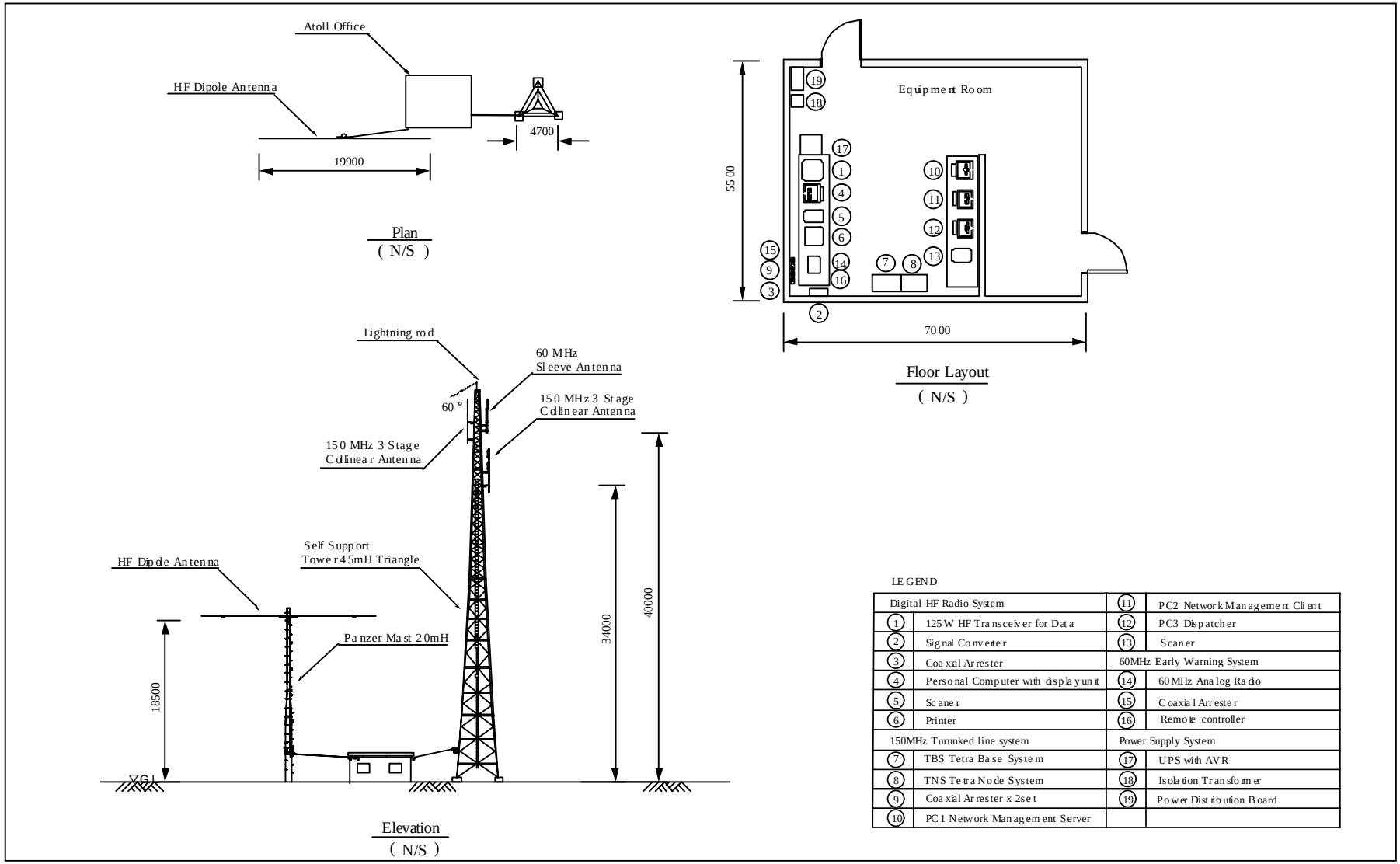
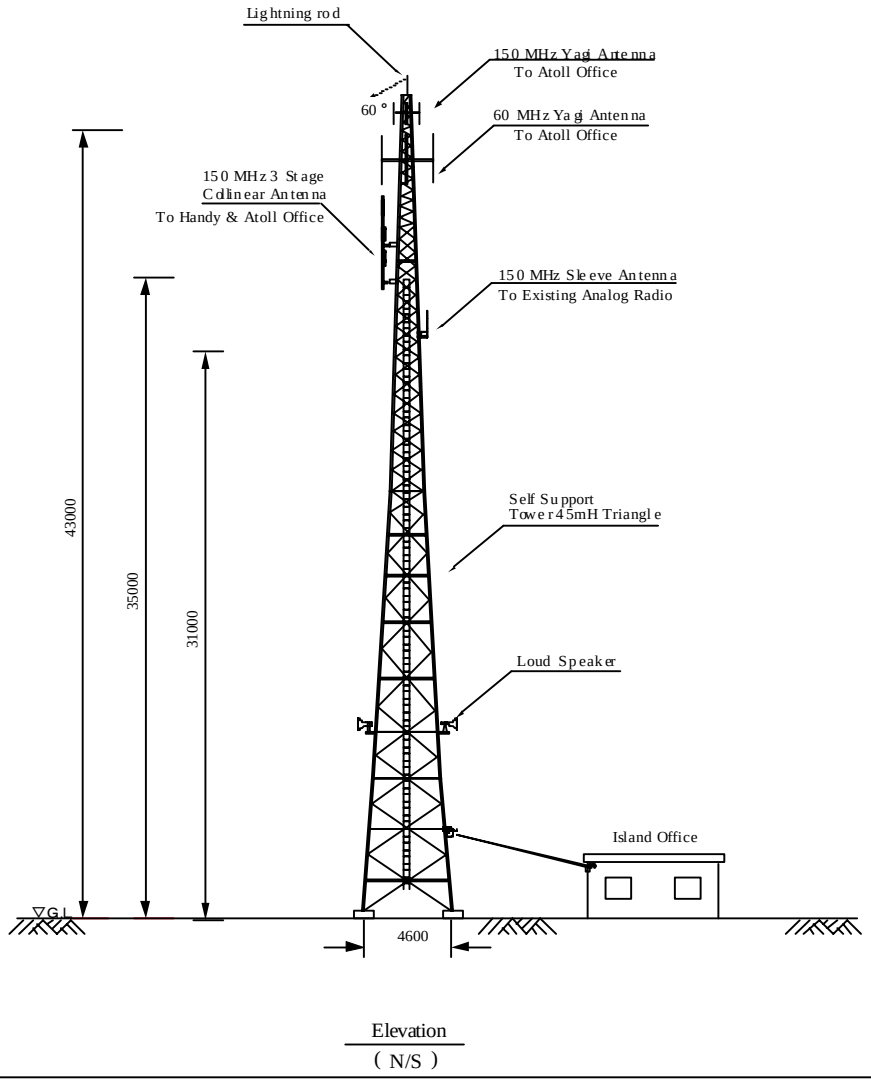
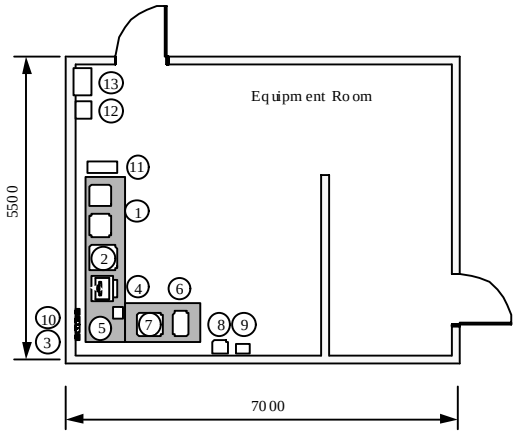


Figure 9. 6 Example of Typical Facility Layout (Atoll Office)



Elevation
(N/S)



Floor Layout
(N/S)

LEGEND

150MHz Turunked line system		Power Supply System	
1	Digital Trunked Radio	11	UPS with AVR
2	150MHz Analog Radio	12	Isolation Transformer
3	Coaxial Arrester	13	Power Distribution Board
4	Personal Computer with display unit		
5	Transfer Switch		
6	Scaner		
7	Printer		
60MHz Early Warning System			
8	60 MHz Analog Radio with Controller		
9	Speaker Controller		
10	Coaxial Arrester		

Figure 9. 6 E Example of Typical Facility Layout (Island Office)

9.5 Preliminary Cost Estimation

9.5.1 Alternatives

The Maldives is located in the northern Indian Ocean. The nation is made up of a long, narrow chain of atolls comprising more than 1190 islands and extends approximately 800 km from the northernmost tip to the southernmost tip. The exclusive economic zone of the Maldives covers about 859,000 km^2.

The project cost changes with the system development scale. From the viewpoint of geographical conditions of the Maldives, cost estimates have been made according to the three alternative development plans as described below.

(1) Alternative-1 (Digital HF for Priority Atolls and VHF Systems for Priority Islands)

Item	Male'	Atoll Offices	Island Offices
Digital HF radio system	1 MOAD	1 Fonadhoo	NA
VHF trunked line system	NA	1 Fonadhoo	5 Ishidhoo, Maabaidhoo, Gan, Fonadhoo, Maavah
VHF early warning system	NA	1 Fonadhoo	5 Ishidhoo, Maabaidhoo, Gan, Fonadhoo, Maavah
Multiplex radio system	3 MOA, NDMC, DOM	NA	NA

(2) Alternative-2 (Digital HF for All Atolls and VHF Systems for Priority Islands)

Item	Male'	Atoll Offices	Island Offices
Digital HF radio system	1 MOAD	20 All Atoll offices	NA
VHF trunked line system	NA	1 Fonadhoo	5 Ishidhoo, Maabaidhoo, Gan, Fonadhoo, Maavah
VHF early warning system	NA	1 Fonadhoo	5 Ishidhoo, Maabaidhoo, Gan, Fonadhoo, Maavah
Multiplex radio system	3 MOA, NDMC, DOM	NA	NA

(3) Alternative-3 (Digital HF for All atolls and VHF Systems for All Inhabited Islands)

Item	Male'	Atoll Offices	Island Offices
Digital HF radio system	1 MOAD	20 All Atoll offices	NA
VHF trunked line system	NA	20 All Atoll offices	200 All inhabited islands
VHF early warning system	NA	20 All Atoll offices	200 All inhabited islands
Multiplex radio system	3 MOA, NDMC, DOM	NA	NA

9.5.2 Cost Estimation

(1) Conditions of cost estimation

The following conditions have been taken in to account for the cost estimation:

- ✓ Installation costs are included in each equipment cost.
- ✓ Installation costs are estimated at 10% of the equipment cost.
- ✓ Miscellaneous costs are estimated at 3% of the equipment cost.
- ✓ Taxes, such as VAT, are *not* included in this cost estimation.
- ✓

(2) Project cost

The cost for executing and completing the Project is estimated to be 616 million Yen for Alternative-1, 342 million Yen for Alternative-2, and 7,323 million Yen for Alternative-3, respectively. A summary of the cost estimation is presented in Table 9.8 below, and the cost breakdown is given on the next page.

Table 9. 8 Summary of the Estimated Project Costs

Item	Alternative-1 (Yen)	Alternative-2 (Yen)	Alternative-3 (Yen)
1. Digital HF Radio System	27,275,000	265,148,000	265,148,000
2. VHF Trunked Line System	149,390,000	149,390,000	3,175,055,000
3. VHF Early Warning System	14,245,000	14,245,000	416,738,000
4. Multiplex System	16,470,000	16,470,000	16,470,000
5. Antenna Towers	108,845,000	124,900,000	2,906,900,000
6. Project Management	25,298,000	45,612,000	542,425,000
Total	**341,523,000**	**615,765,000**	**7,322,736,000**

1. Alternative-1

	ITEM	Q'ty	Price (JPY)
1. DIGITAL HF RADIO SYSTEM			
1) Base Station (Male)			
1-1	125W HF Transmitter & Receiver	1	3,800,000
1-2	Antenna system	1	4,480,000
1-3	Communication controller with Software	1	4,300,000
1-4	External devices	1	145,000
1-5	UPS	1	1,000,000
1-6	Isolation transformer	1	600,000
1-7	Miscellaneous		430,000
	Sub-Total 1-1)		14,755,000
2) Remote Station (Atoll Office)			
2-1	125W HF Transmitter & Receiver	1	3,800,000
2-2	Antenna system	1	2,310,000
2-3	Communication controller with Software	1	4,300,000
2-4	External devices	1	145,000
2-5	AC power supply and UPS	1	1,000,000
2-6	Isolation transformer	1	600,000
2-7	Miscellaneous		365,000
	Sub-Total 1-2)		12,520,000
2. VHF TRUNKED LINE SYSTEM			
1) Base Station (Atoll Office)			
1-1	10W Master Radio System	1	42,200,000
1-2	Node System	1	67,000,000
1-3	Network /Subscriber Management System	1	14,200,000
1-4	Antenna system	1	3,250,000
1-5	Line Dispatcher	1	9,214,000
1-6	AC power supply and UPS	1	85,000
1-7	Miscellaneous		4,078,000
	Sub-Total 2-1)		140,027,000
2) Fixed Station (Island Office)			
2-1	10W Subscriber Radio	5	1,000,000
2-2	External devices	5	5,630,000
2-3	Antenna system	5	225,000
2-4	AC power supply and UPS	5	900,000
2-5	Miscellaneous		233,000
	Sub-Total 2-2)		7,988,000
3) Portable Station			
3-1	Portable radio terminal	5	1,375,000
	Sub-Total 2-3)		1,375,000
3. VHF EARLY WARNING SYSTEM			
1) Master station (Atoll Office)			
1-1	10W Radio System with master controller	1	6,500,000
1-2	Antenna system	1	350,000
1-3	AC power supply and UPS	1	180,000
1-4	Isolation transformer	1	400,000
1-5	Miscellaneous		223,000
	Sub-Total 3-1)		7,653,000
2) Speaker Warning Station (Island Office)			
2-1	10W Radio System with remote controller	5	2,500,000
2-2	Antenna system	5	450,000
2-3	AC power supply and UPS	5	1,000,000
2-4	Loudspeaker	5	450,000
2-5	Isolation transformer	5	2,000,000
2-6	Miscellaneous		192,000
	Sub-Total 3-2)		6,592,000
4. MULTIPLEX RADIO SYSTEM			
1)	8.2GHz Multiplex radio	3	11,400,000
2)	Antenna system	3	540,000
3)	AC power supply and UPS	3	3,000,000
4)	Isolation transformer	3	1,050,000
5)	Miscellaneous		480,000
	Sub-Total 4		16,470,000
5. ANTENNA TOWER			
1)	TOWER (20m Self Supporting Square Type)	3	30,000,000
2)	TOWER (45m Self Supporting Triangle Type)	6	78,000,000
3)	TOWER (25m Panza Mast)	1	845,000
	Sub-Total 5		108,845,000
	Total equipment cost		**316,225,000**
6. MANAGEMENT COST			
1)	Project Management Cost	1	25,298,000
	GROUND TOTAL (Alternative-1)		**341,523,000**

2. Alternative-2

	ITEM	Q'ty	Price (JPY)
1. DIGITAL HF RADIO SYSTEM			
1) Base Station (Male)			
1-1	125W HF Transmitter & Receiver	1	3,800,000
1-2	Antenna system	1	4,480,000
1-3	Communication controller with Software	1	4,300,000
1-4	External devices	1	145,000
1-5	UPS	1	1,000,000
1-6	Isolation transformer	1	600,000
1-7	Miscellaneous		430,000
	Sub-Total 1-1)		14,755,000
2) Remote Station (Atoll Office)			
2-1	125W HF Transmitter & Receiver	20	76,000,000
2-2	Antenna system	20	46,200,000
2-3	Communication controller with Software	20	86,000,000
2-4	External devices	20	2,900,000
2-5	AC power supply and UPS	20	20,000,000
2-6	Isolation transformer	20	12,000,000
2-7	Miscellaneous		7,293,000
	Sub-Total 1-2)		250,393,000
2. VHF TRUNKED LINE SYSTEM			
1) Base Station (Atoll Office)			
1-1	10W Master Radio System	1	42,200,000
1-2	Node System	1	67,000,000
1-3	Network /Subscriber Management System	1	14,200,000
1-4	Antenna system	1	3,250,000
1-5	Line Dispatcher	1	9,214,000
1-6	AC power supply and UPS	1	85,000
1-7	Miscellaneous		4,078,000
	Sub-Total 2-1)		140,027,000
2) Fixed Station (Island Office)			
2-1	10W Subscriber Radio	5	1,000,000
2-2	External devices	5	5,630,000
2-3	Antenna system	5	225,000
2-4	AC power supply and UPS	5	900,000
2-5	Miscellaneous		233,000
	Sub-Total 2-2)		7,988,000
3) Portable Station			
3-1	Portable radio terminal	5	1,375,000
	Sub-Total 2-3)		1,375,000
3. VHF EARLY WARNING SYSTEM			
1) Master station (Atoll Office)			
1-1	10W Radio System with master controller	1	6,500,000
1-2	Antenna system	1	350,000
1-3	AC power supply and UPS	1	180,000
1-4	Isolation transformer	1	400,000
1-5	Miscellaneous		223,000
	Sub-Total 3-1)		7,653,000
2) Speaker Warning Station (Island Office)			
2-1	10W Radio System with remote controller	5	2,500,000
2-2	Antenna system	5	450,000
2-3	AC power supply and UPS	5	1,000,000
2-4	Loudspeaker	5	450,000
2-5	Isolation transformer	5	2,000,000
2-6	Miscellaneous		192,000
	Sub-Total 3-2)		6,592,000
4. MULTIPLEX RADIO SYSTEM			
1)	8.2GHz Multiplex radio	3	11,400,000
2)	Antenna system	3	540,000
3)	AC power supply and UPS	3	3,000,000
4)	Isolation transformer	3	1,050,000
5)	Miscellaneous		480,000
	Sub-Total 4		16,470,000
5. ANTENNA TOWER			
1)	TOWER (20m Self Supporting Square Type)	3	30,000,000
2)	TOWER (45m Self Supporting Triangle Type)	6	78,000,000
3)	TOWER (25m Panza Mast)	20	16,900,000
	Sub-Total 5		124,900,000
	Total equipment cost		**570,153,000**
6. MANAGEMENT COST			
1)	Project Management Cost	1	45,612,000
	GROUND TOTAL (Alternative-1)		**615,765,000**

3. Alternative-3

	ITEM	Q'ty	Price (JPY)
1. DIGITAL HF RADIO SYSTEM			
1) Base Station (Male)			
1-1	125W HF Transmitter & Receiver	1	3,800,000
1-2	Antenna system	1	4,480,000
1-3	Communication controller with Software	1	4,300,000
1-4	External devices	1	145,000
1-5	UPS	1	1,000,000
1-6	Isolation transformer	1	600,000
1-7	Miscellaneous		430,000
	Sub-Total 1-1)		14,755,000
2) Remote Station (Atoll Office)			
2-1	125W HF Transmitter & Receiver	20	76,000,000
2-2	Antenna system	20	46,200,000
2-3	Communication controller with Software	20	86,000,000
2-4	External devices	20	2,900,000
2-5	AC power supply and UPS	20	20,000,000
2-6	Isolation transformer	20	12,000,000
2-7	Miscellaneous		7,293,000
	Sub-Total 1-2)		250,393,000
2. VHF TRUNKED LINE SYSTEM			
1) Base Station (Atoll Office)			
1-1	10W Master Radio System	20	844,000,000
1-2	Node System	20	1,340,000,000
1-3	Network /Subscriber Management System	20	284,000,000
1-4	Antenna system	20	65,000,000
1-5	Line Dispatcher	20	184,280,000
1-6	AC power supply and UPS	20	1,700,000
1-7	Miscellaneous		81,569,000
	Sub-Total 2-1)		2,800,549,000
2) Fixed Station (Island Office)			
2-1	10W Subscriber Radio	200	40,000,000
2-2	External devices	200	225,200,000
2-3	Antenna system	200	9,000,000
2-4	AC power supply and UPS	200	36,000,000
2-5	Miscellaneous		9,306,000
	Sub-Total 2-2)		319,506,000
3) Portable Station			
3-1	Portable radio terminal	200	55,000,000
	Sub-Total 2-3)		55,000,000
3. VHF EARLY WARNING SYSTEM			
1) Master station (Atoll Office)			
1-1	10W Radio System with master controller	20	130,000,000
1-2	Antenna system	20	7,000,000
1-3	AC power supply and UPS	20	3,600,000
1-4	Isolation transformer	20	8,000,000
1-5	Miscellaneous		4,458,000
	Sub-Total 3-1)		153,058,000
2) Speaker Warning Station (Island Office)			
2-1	10W Radio System with remote controller	200	100,000,000
2-2	Antenna system	200	18,000,000
2-3	AC power supply and UPS	200	40,000,000
2-4	Loudspeaker	200	18,000,000
2-5	Isolation transformer	200	80,000,000
2-6	Miscellaneous		7,680,000
	Sub-Total 3-2)		263,680,000
4. MULTIPLEX RADIO SYSTEM			
1)	8.2GHz Multiplex radio	3	11,400,000
2)	Antenna system	3	540,000
3)	AC power supply and UPS	3	3,000,000
4)	Isolation transformer	3	1,050,000
5)	Miscellaneous		480,000
	Sub-Total 4		16,470,000
5. ANTENNA TOWER			
1)	TOWER (20m Self Supporting Square Type)	3	30,000,000
2)	TOWER (45m Self Supporting Triangle Type)	220	2,860,000,000
3)	TOWER (25m Panza Mast)	20	16,900,000
	Sub-Total 5		2,906,900,000
	Total equipment cost		**6,780,311,000**
6. MANAGEMENT COST			
1)	Project Management Cost	1	542,425,000
	GROUND TOTAL (Alternative-1)		**7,322,736,000**

9.6 Preliminary Implementation Schedule

Table 9.9 below presents a preliminary schedule for implementing the project via the JBIC loan scheme. The total implementation period for Alternative-1 is assumed to be 44 months from the date of approval of the Project until the end of the Project. The number of months required for each of major implementation process is estimated as follows:

1) 12 months for the selection of consultants.
2) 5 months for the detailed design and preparation of tender documents, including concurrence of JBIC.
3) 5 months for the tender evaluation, including concurrence of JBIC.
4) 10 months for the system design, procurement, development, manufacturing, installation and testing of both the software and hardware.
5) 2 months for training.

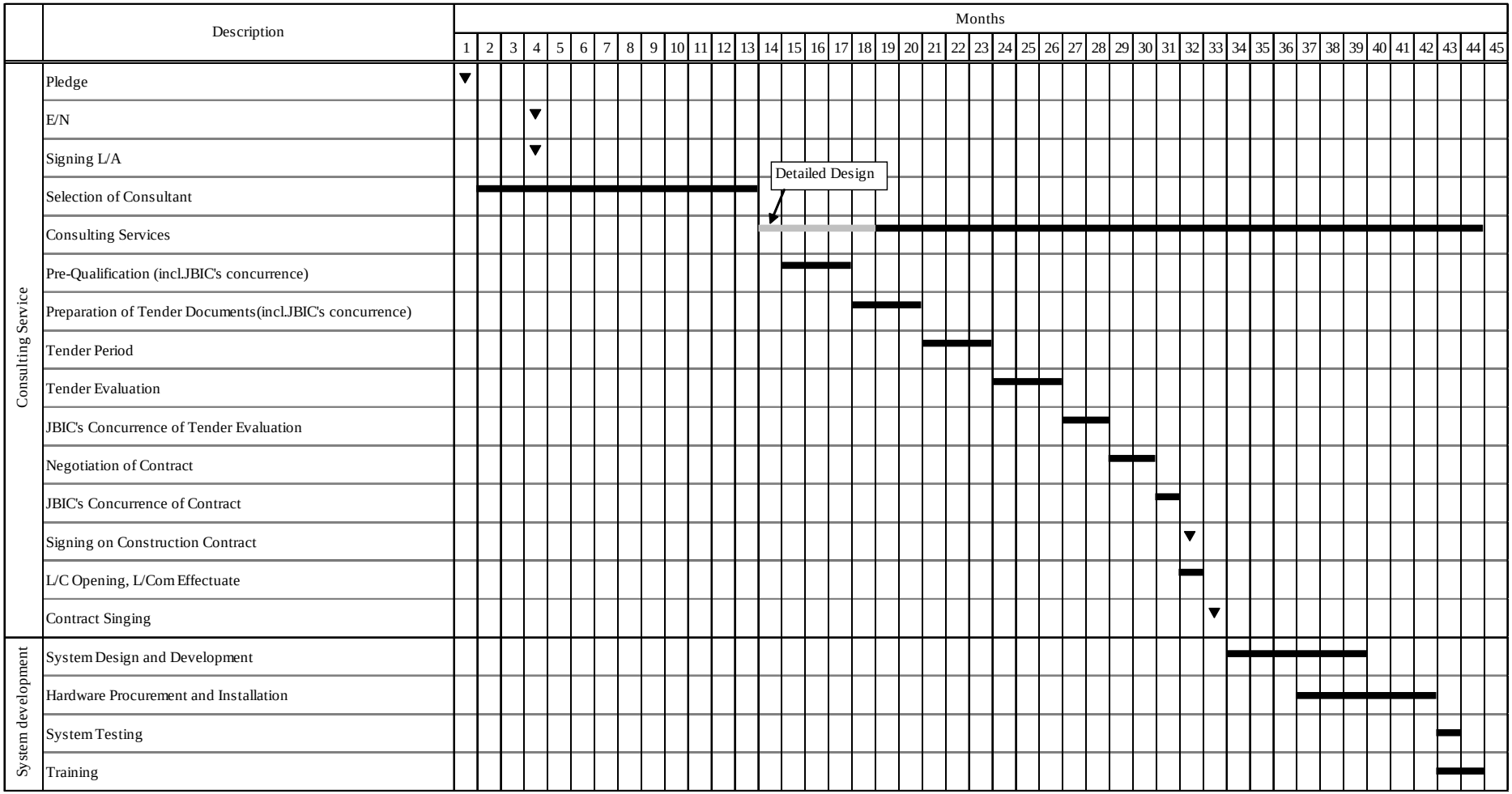
In addition to the above, the following actions and procedures need to be completed before the contract is signed:

1) Tendering.
2) Pre-Qualification of contractors.
3) Construction contract negotiation.
4) Approval of the construction contract by JBIC.

For JBIC funding, the standard procedural times for loan project administration are prescribed as follows:

1) Selection of Consulting Firms: 12 months
2) Construction/Procurement of Equipment: 23 months in total, as follows:
   - a. Pre-Qualification: 4 months
   - b. Preparation of Tender Documents: 3 months
   - c. Tender Period: 3 months
   - d. Evaluation of Tenders: 6 months
   - e. JBIC Concurrence for Tender Evaluation: 2 months
   - f. Contract Negotiation: 3 months
   - g. JBIC Concurrence for Contract: 1 month
   - h. Opening a Letter of Credit: 1 month

Table 9. 9 Preliminary Implementation Schedule



9.7 Recommendations

Communications in the Maldives is dependent on the public telephone service. Because of this, each island is not able to communicate with other places when the public telephone network is out of service. From the viewpoint of disaster prevention, it is concluded that an alternative communications network, which is not affected by disasters, needs to be developed. However, in order to improve the functionality of the system, the following actions are required in the medium and long term:

(1) Improvement of related legal systems

In the Maldives, there are currently no protocols for natural disaster prevention. In order to identify the organizations concerned, clarify their roles, functions and responsibilities, a national disaster framework and related legal system are required. An outline of the Disaster Measures Basic Law in Japan is shown below.

Table 9. 10 Outline of Disaster Measures Basic Law in Japan

Chapter 1	General Rules (Articles 1 to 10)
Chapter 2	Organizations Related to Disaster Prevention Section 1 Central Disaster Prevention Council (Articles 11-13) Section 2 Local Disaster Prevention Council (Articles 14-23) Section 3 Emergency Center and Disaster Headquarters (Articles 24-28.6) Section 4 Dispatch of Personnel in Case of Emergency (Articles 29-33)
Chapter 3	Disaster Prevention Plan (Articles 34-45)
Chapter 4	Disaster Prevention (Articles 46-49)
Chapter 5	Emergency Response Measures Section 1 General Principles (Articles 50-53) Section 2 Warnings and Other Communications (Articles 54-57) Section 3 Proactive Measures and Evacuation (Articles 58-61) Section 4 Response Measures (Articles 62-86)
Chapter 6	Post-disaster Recovery (Articles 87-90)
Chapter 7	Financial and Monetary Measures (Articles 91-104)
Chapter 8	Disasters and Emergencies (Articles 105-109.2)
Chapter 9	Miscellaneous Rules (Articles 110-112)
Chapter 10	Penalty Rules (Articles 113-117)
Additional Rules	

(2) Establishment of organizational structures

Disaster prevention needs to be implemented integrally and systematically with the cooperation of the national government, regional government, public institutions and residents. Organizational structures and information flows have briefly been studied in this report. However, based on the needs of the alternative communications system and related legal system, an actual organizational structure at the national, regional and municipal levels needs to be established.

(3) Balance of demands and project objectives

There are several needs from several organizations that must be balanced to allow effective communication between islands and atolls, and between atolls and capital Male'. The demands vary even within each organization. The Study Team recognizes that these demands form the present conditions and that almost all organizations are dependent on the public telecommunication network for their own business. However, it is important to balance these various demands and project objectives.

(4) Participation of related parties

In contrast to balancing demand and project objectives, it is effective to increase the number of system users in order to maximize the project benefit. To identify potential users, further analysis will be required of business procedures in related organizations at both atoll and island levels. For example, in order to increase the number of tourists, enhancement of the disaster prevention capability is required. Development of an alternative communication network is one of the solutions. In this sense, tourist islands would be considered as candidates for the related parties.

(5) Detailed design

The Study has discussed the current situation in the telecommunications sector in the Maldives, the impact of the 2004 tsunami, and the existing organizational structures relevant to disaster prevention. Based on these analyses, the Study Team has proposed that an alternative telecommunications system be developed. The proposal includes the necessity for development, an outline of the required organizational structure, preliminary system design, cost estimation and an implementation schedule. However, the system design that is described in this report is only preliminary, as necessary for clarifying the project scale. In the project implementation stage, detailed design work will be required.

CHAPTER 10 ENVIRONMENTAL CONSIDERATIONS

10.1 Introduction

This Chapter looks into the environmental aspect of the six infrastructure projects included in the Study, which are multi-purpose building & island office, causeway, power supply, sewerage system, island harbours and coastal protection. Each project has different development characteristics, and varies significantly in the impact on the natural and social environment.

In accordance to the GOM environmental law "Environment Protection and Preservation Act (Law no.: 4/93)", all development projects will require an environmental approval from Ministry of Environment, Energy and Water (MEEW) (former name: Ministry of Environment and Construction (MEC)), and an IEE or EIA will be required for development projects with significant environmental impacts (refer to Chapter 10.2 for more details on the environmental legislation of GOM).

Within the six development projects, multi-purpose building & island office, causeway, power supply and sewerage system are grant aid projects. For the grant aid projects an application form was submitted to MEEW to obtain environmental approval, and IEE was requested for the causeway and EIA for the sewerage projects as a condition of approval. After submission of necessary documents all the grant aid projects have obtained environmental approval from MEEW.

For the medium-term projects (island harbour and coastal protection), no application forms are submitted to MEEW, since the projects are still in its preliminary stage. However, the Team has conducted an original IEE for the island harbour, since certain level of environmental impacts can be observed from the project.

Table 10.1 summarizes the status of environmental approval of each project.

Table 10.1 Status of Environmental Approval of each Project by MEEW

	Requirement of IEE or EIA	Environmental approval of MEEW
Multi-purpose building & Island office	Not required	Approval obtained
Causeways	IEE required	Approval obtained after submitting IEE
Power supply	Not required	Approval obtained
Sewage system	EIA required	Approval obtained after submitting EIA
Island harbours	Not applied to MEEW yet, but IEE could be required	-
Coastal protection	Not applied to MEEW	-

In the following Chapters, only the island harbours, causeways and sewerage projects will be focused, since the other projects have only negligible impact on the environment. A summary of the submitted IEE of the causeway and EIA of the sewerage projects will be presented, together

with the original IEE conducted for the island harbours.

All the information contained in this Chapter is compiled through reference to literature, interview surveys, aerial photos, field reconnaissance in May 2005 and simple field surveys.

10.2 Environmental Legislation in the Maldives

10.2.1 Environmental Regulations applied to Development Project

The basic environmental law in the Maldives is “Environment Protection and Preservation Act (Law no.: 4/93)”. Under Clause 5 of this law, all development projects irrespective of its project scale will require an environmental approval from the MEEW. For development projects with potential environmental impact, an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) will be requested as a condition of approval. The above approval process will also apply to tsunami reconstruction projects, though the evaluation process of the MEEW may be fasten due to the urgent nature of the projects.

10.2.2 Process of Obtaining the Environmental Approval

In order to obtain the Environmental Approval from MEEW, the project proponent must initially submit a Screening Form, providing a brief description of the project and environmental impacts. Based on the Screening Form, MEEW will determine whether an IEE or EIA is necessary.

Both IEE and EIA are usually composed of; description of the existing environmental condition, environmental impact assessment, mitigation measures and monitoring plan. However, IEE requires less information, no original research and less rigorous analysis compared to EIA.

In some cases MEEW may request an EIA when significant environmental impact is identified after conducting the IEE. The basic procedure for obtaining Environmental Approval is also described in the following flow chart (Figure 10.1).

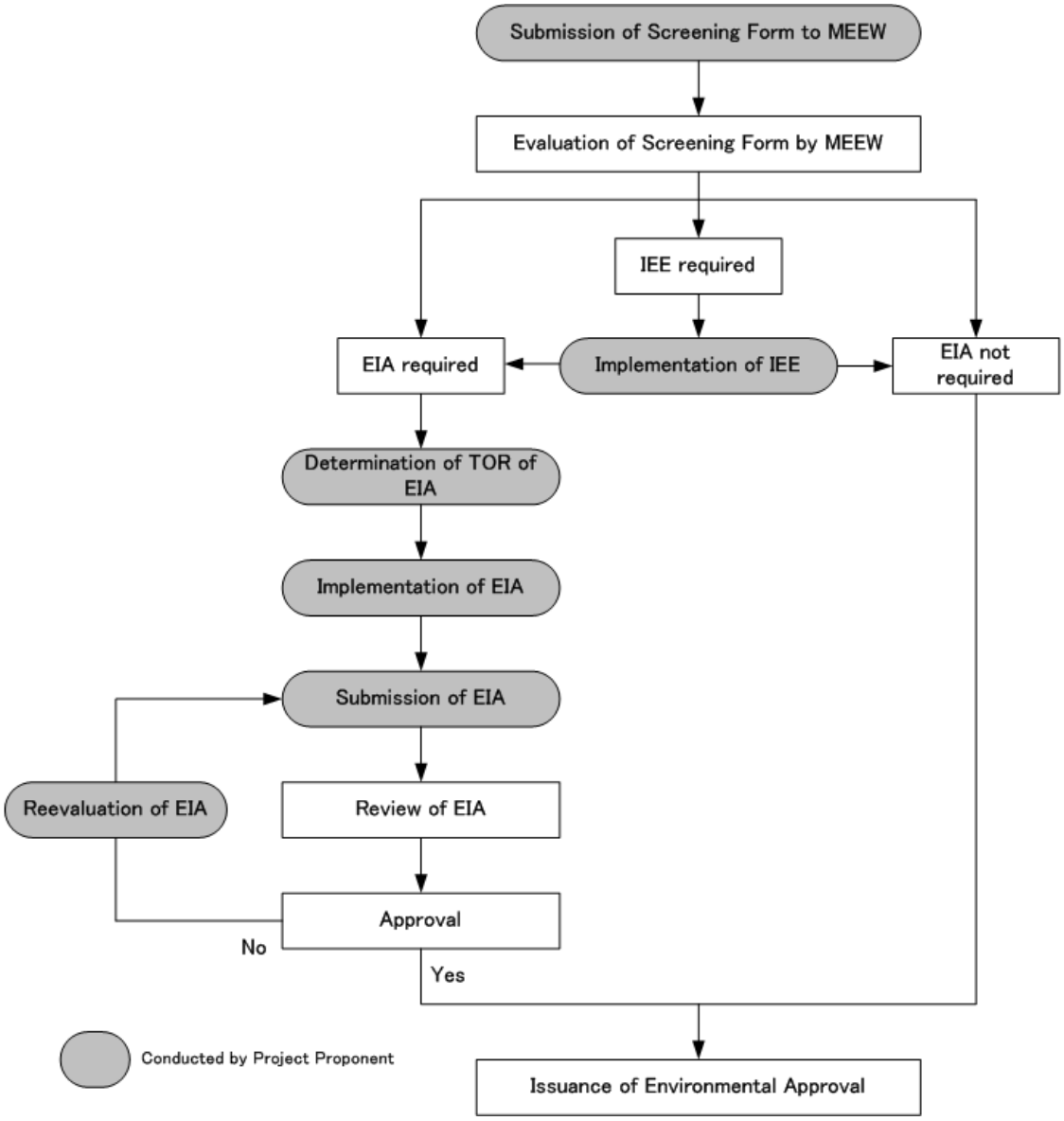


Figure 10.1 Basic Procedure for Obtaining Environmental Approval

10.3 IEE of the Reconstruction of the 11 Island Harbours

10.3.1 Existing Status of the Island Harbours

Following is a brief description of the existing status of the island harbours, which is based on the field reconnaissance conducted in May 2005.

In total, 11 island harbours were surveyed during the field reconnaissance of May 2005. All the harbours are located facing the inner atoll. The harbours can be classified into two types of harbour structure. The first type, which is most common, is constructed over a reef flat. Since reef flats are shallow it has been excavated and dredged to create the channel and harbour area. The photo below shows a typical harbour of this type.

Typical Harbour Constructed Over a Reef Flat

The second type of harbour is constructed inside a natural lagoon. This type of harbour usually does not require a seawall or breakwater due to the sheltered nature of the lagoon. However, the reef edge must be excavated and dredged to create the shipping channel. The photo below shows a typical harbour of this type.

Typical Harbour Constructed Inside a Lagoon

Although many of the harbours were already damaged to a certain degree prior to the tsunami, the tsunami has accelerated these damages. The main damages observed during the field reconnaissance were, cracks and tilting of the quay wall, and collapsing of seawall and breakwater. Also coastal erosion was observed along the coast of some harbours. Prompt reconstruction of the harbours will be essential to sustain the harbour function and the safety of the users.

10.3.2 Existing Status of Natural and Social Environment around the Island Harbours

(1) Natural Environment around the Island Harbours

1) Geography

Islands in the atolls are built over a shallow reef flat (around 1m depth), which could sometimes be exposed during low tide. The shallow reef flat continues until it reaches the reef edge, then rapidly slopes down to greater depth at the reef slope. In some islands, a lagoon has developed inside the reef flat.

2) Climate

Climate information is based on the meteorological data of Kaddhoo Airport in Laamu Atoll. Monthly average temperature shows little fluctuation with the season, ranging between 28 to 29℃. Monthly mean relative humidity show little fluctuation with the season, ranging mostly between 70 – 80%.

Laamu Atoll has relatively high amount of rainfall with an annual rainfall of around 2,000mm. Generally rainfall is most abundant during October and November, sometimes exceeding 400mm. Rainfall is usually least during February and March, often being below 100mm. The other months are between 100 – 200mm.

Wind direction is strongly influenced by the two monsoon season. Easterly winds dominate during the NE monsoon season (January – March) and westerly winds during SW monsoon season (May – November). Wind direction is variable in between the two monsoon seasons. Wind speed is quite variable with the season but generally strongest during the SW monsoon season.

3) Shoreline Erosion

Shoreline erosion is a serious problem in Maldives. Many of the coasts adjacent to the harbours appeared to be significantly eroded. The photo below shows an eroded coast adjacent to the harbour. Various factors may be the cause, such as global warming, tsunami, increase in severe weather, reduction of sand supply due to less corals and so on.

Coastal Erosion Along the Coast Adjacent to the Harbour
(Photo taken in May 2005)

4) Seawater Quality

Seawater quality data of the island harbours were not available. However, obvious deterioration of water quality was observed in many of the island harbours during the harbour survey in May 2005.

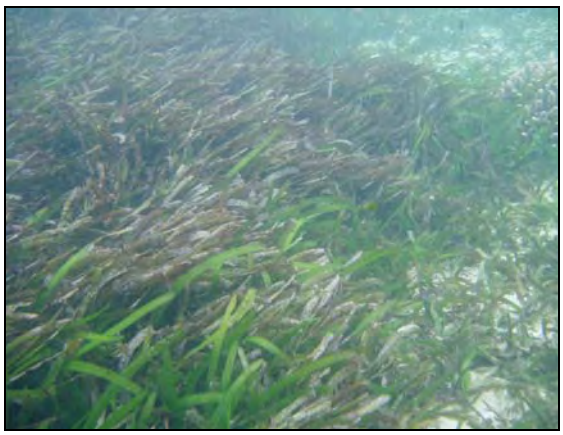
Water transparency inside the harbours were significantly lower compared to the outer harbour area, which is an indication of water deterioration inside the harbour. As a general trend, transparency was lower with harbours with long shipping channel. The main factor behind the water quality deterioration is likely due to the restriction in water exchange between the inner and outer harbour area.

Furthermore, large amounts of wastes such as dead fish, plastic bottles and various debris were observed inside the harbours and along the coast as shown in the photo below;

Various Waste Observed in the Adjacent Coast of the Island Harbour
(Photo taken in May 2005)

5) Marine Ecosystem

Seagrass beds are often densely distributed in the shallow reef flats adjacent to the harbours. The main species is *Thalassia hemprichii*. Figure 10.6 shows a photo of the *Thalassia hemprichii* bed found near one of the harbour.



Thalassia hemprichii Bed Found Near One of the Harbour

(Photo taken in May 2005)

During the field reconnaissance, patches of corals were sometimes found inside the harbours and channels, though at very low density. Furthermore, many of the observed corals appeared to be dead, thus having very little conservation value.

In the Maldives, corals are usually most densely distributed along the reef edge, where the shipping channel ends. Since, survey of this area could not be conducted further survey will be required.

Sea turtles are known to nest in some of the islands of both Atolls. The main species are hawksbill turtle (*Eretmochelys imbricata*) and green sea turtle (*Chelonia mydas*). Table 10.2 lists the islands noted for sea turtle nesting. However, since the nesting sites are usually located in the sandy beaches facing the outer atoll, the harbour reconstruction works will not affect the nesting sites.

Table 10.2 Sea Turtle Nesting Islands in Laamu and Thaa Atoll

Laamu Atoll	Thaa Atoll
Isdhoo	Buruni
Gan (Mathimaradhoo)	Maagulhi
Kaddhoo	Dhonanfushi
Gaadhoo	Kanimeedhoo
	Veymandhoo
	Kinbidhoo
	Kakolhas
	Olhufushi Finolhu
	Olhufushi

Source: Marine Research Center

(2) Social Environment of the Islands

1) Demography

The following Table 10.3 shows the population of the islands where the Island harbours are located. All islands have a population of less than 2,000.

Table 10.3 Population of the Islands where the Island Harbours are Located (Year 2000)

Laamu Atoll	Isdhoo	1,432
	Maabaidhoo	793
	Fonadhoo	1,740
	Maavah	1,351
Thaa Atoll	Dhiyamigili	484
	Guraidhoo	1,433
	Thimarafushi	1,537
	Veymandhoo	763
	Kinbidhoo	833
	Hirilandhoo	759

Source: Statistical Yearbook of Maldives 2004

2) Socio-economic Activities

Fisheries is the dominant socio-economic activity in most of the islands. The main targeted species are tuna and skipjack, which are caught by pole and line in the offshore waters. Other fisheries include reef fishery, bait fishery and sea cucumber fishery. In some harbours, cages for baitfish, which are used for tuna and skipjack fishing where placed inside the harbour area.

In recent years, fish catch are often sold directly to international freezer vessels or to fish processing factories such as in Maandhoo. Despite this trend, fishing landing activities where still observed in many of the harbours. Also smoking and drying of fish where conducted in some of the harbours, such as in Hirilandhoo of Thaa Atoll. Table 10.4 summarizes the number of fishing households, fishing vessels and the maximum number of vessel call per day of each island.

Table 10.4 The Number of Fishing Households, Fishing Vessels and Maximum Number of Vessel Calls per Day of each Island

	Island	No. of fishing household (estimate)	No. of fishing vessels	Maximum no. of vessel calls per day*
Laamu Atoll	Isdhoo	0	Data N/A	Data N/A
	Maabaidhoo	50	13	40
	Fonadhoo	10	2	35
	Maavah	130	22	70
Thaa Atoll	Dhiyamigili	55	23	55
	Guraidhoo	45	30	Data N/A
	Thimarafushi	58	16	54
	Veymandhoo	45	31	90
	Kinbidhoo	39	10	40
	Hirilandhoo	50	27	50

*: Includes transport vessels

Source: Based on interview survey of island office

Despite the relatively small scale of the harbours, frequency of vessel calls could be quite high. Therefore, careful planning of reconstruction works must be made so to minimize obstruction to the vessels movement.

Agriculture is conducted at a subsidiary level in some of the islands. Products include coconut, mango, eggplant, chili, water melon, pumpkin, cucumber and so on.

3) Waste Management

During the field reconnaissance various wastes, such as plastic bottles, dead fish and debris where observed inside the harbour area and along the adjacent coast. Clean-up of these waste and awareness campaigns should be conducted in the future so to minimize uncontrolled waste dumping.

10.3.3 Description of the Reconstruction Works

The main works required for the reconstruction of the island harbours are quay wall, quay wall apron, seawall and breakwater repair and coastal protection. Initially dredging of harbour basin was also considered. However, in accordance to the bathymetric survey conducted in May 2005, the water depth of all the harbour basins were above the minimum acceptable depth (i.e. 8ft above L.A.T). Therefore, dredging of harbour basin is considered unnecessary for all the harbours. Table 10.5, shows the approximate length of repair required for the main harbour structures, and coastal protection.

Table 10.5 Approximate Length of Repair Required for the Main Harbour Structures, and the Required Length of Coastal Protection

Atoll	Harbour	Quay wall (m)	Quay wall apron (m)	Seawall (m)	Breakwater (m)	Coastal protection (m)
Laamu	Isdhoo	10 (108)*	108 (108)	60 (168)	70 (70)	-
	Isdhoo-Kalaidoo	-	93 (93)	-	-	120
	Maabaidhoo	96 (131)	131 (131)	-	-	110
	Fonadhoo	82 (168)	168 (168)	-	157 (285)	100
	Maavah	123 (173)	173 (173)	-	-	50
Thaa	Dhiyamigili	192 (215)	27 (215)	52 (162)	600 (800)	-
	Guraidhoo	25 (304)	224 (304)	70 (269)	85 (205)	-
	Thimarafushi	-	216 (216)	-	-	-
	Veymandhoo	-	-	-	-	-
	Kinbidhoo	54 (54)	54 (54)	8 (103)	-	-
	Hirilandhoo	-	141 (141)	-	-	-

*: Figures in the parenthesis indicate the approximate length of the existing structure

10.3.4 Potential Environmental Impacts

Since the scale of the reconstruction works are relatively small, adverse impacts on the natural and social environment will generally be minor. However, the following impacts could still be expected during the construction phase.

- Impacts on the adjacent seagrass and corals through dispersion of sediments by harbour repair works. Sediment dispersion will be most significant for harbours requiring seawall repair, since construction of a temporary road will be required for backhoe mobilization. Sediment dispersion will be insignificant for activities related to quay wall, breakwater and coastal protection works.
- Impacts to the harbours users, such as fishing vessels and transport vessels, through temporal restriction in the use of quay wall and quay wall apron.

The magnitude of the above impacts will vary with the harbours due to the differences in the construction scale and the local environment status. Table 10.6 summarizes how the above impacts will affect each harbour through consideration of construction scale and harbour characteristics.

Table 10.6 Magnitude of the Impacts of the Reconstruction Works in Respect to Seagrass, Corals and Harbour Users

Atoll	Harbour	Seagrass	Corals	Harbour users
Laamu	Isdhoo	C	U	C
	Isdhoo-Kalaidoo	D	D	C
	Maabaidhoo	D	D	B
	Fonadhoo	D	D	B
	Maavah	D	D	B
Thaa	Dhiyamigili	C	U	B
	Guraidhoo	U	U	C
	Thimarafushi	D	D	C
	Veymandhoo	D	D	D
	Kinbidhoo	D	D	B
	Hirilandhoo	D	D	C

A: Significant potential impact, B: Moderate potential impact, C: Small potential impact, D: No potential impact, U: Undecided (not enough information)

Impact on the seagrass should be limited to Isdhoo and Dhiyamigili, since these harbours require seawall reconstruction. However, impact on seagrass will be further reduced for Isdhoo and Dhiyamigili if construction of temporal road is unnecessary for the seawall repair. Although Guraidhoo requires seawall reconstruction it appears that there are no seagrass near the harbour according to the aerial photo. Kinbidhoo also requires seawall reconstruction but impact on seagrass will be insignificant due to the short length of seawall reconstruction (8m). Impact on the corals is possible for Isdhoo, Dhiyamigili and Guraidhoo. However, the distribution of corals around these harbours is uncertain. Perhaps a coral survey should be conducted around these harbours prior to construction.

The most significant concern during the harbour reconstruction is the impact on the harbour users, especially with harbours requiring major quay wall reconstruction. Harbours that apply to this category are Maabaidhoo, Fonadhoo, Maavah, Dhiyamigili and Kinbidhoo.

10.3.5 Mitigation Measures

In order to minimize the above identified impacts, employment of the following mitigation measures are proposed:

- Installation of silt protection curtain to minimize sediment dispersion during seawall construction.
- Maintenance of enough quay wall space for the harbour users. Careful planning of construction works will be required, with full consultation with the harbour users.
- Prior notice of the construction schedule to the harbour users.

10.3.6 Environmental Monitoring Plan

Environmental monitoring of the natural environment will not be a high priority for most harbours, since the magnitude of the impacts on the natural environment are relatively minor. However, if major coral communities are identified near the harbour, appropriate monitoring should be conducted.

Since the most significant concern during the harbour reconstruction is the impact on the harbour users, regular interview surveys should be conducted to the harbour users, so that their opinions are constantly reflected back in the construction method.

10.4 IEE of the Reconstruction of the Two Causeways in Laamu Atoll

10.4.1 Existing Status of the Two Causeways

In this report, the causeway that connects Kaddhoo Island to Maandhoo Island is named as Causeway No.1, and the other causeway that connects Kaddhoo Island to Fonadhoo Island as Causeway No.2. Both causeways function as an important transport lifeline for these islands. Table 10.7 shows the length and width of the two causeways prior to the tsunami. Almost the entire half lane of Causeway No.2 has been scraped away through the tsunami. Damage to Causeway 1 is slightly less but some sections have been scraped away significantly.

Table 10.7 The Length and Width of the Causeways Prior to the Tsunami

	Causeway No.1 (Maandhoo – Kaddhoo)	Causeway No.2 (Kaddhoo – Fonadhoo)
Length	270m	812m
Width	13m (two lane)	13m (two lane)

Since some sections of the causeways are narrowed to one lane, vehicles must wait at a wide section until the opposing vehicle passes. Furthermore, the existing sections of the causeways are under rapid and continues erosion. Prompt reconstruction of the causeways is essential for the local users.

10.4.2 Existing Status of Natural and Social Environment around the Causeways

(1) Natural Environment around the Causeways

1) Geography

The two causeways are built over a shallow reef flat (around 1m depth). Figure 10.2 shows the geographical structure around the causeways. The west side of the causeway is slightly shallower than the east side due to accumulation of sediments.

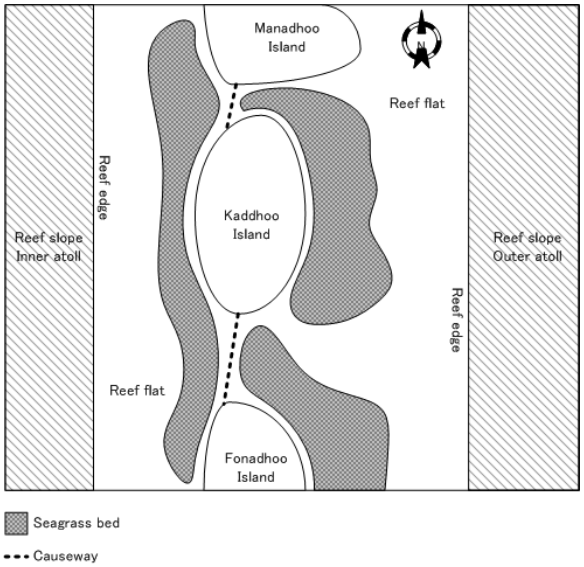


Figure 10.2 Geographical Structure around the Causeway

2) Climate

Refer to Chapter 10.3.2.

3) Oceanography

There was no reliable information source that describes the oceanographic characteristics around the causeways. Therefore description of this section is mainly based on deduction and the field reconnaissance of May 2005. Since the causeways are located over a reef flat, the adjacent water depth is shallow. Interestingly, water depth of the west side was noticeably lower compared to the east side. A combination of factors may be the cause, such as limitation in water exchange, tidal time difference and the effect of the breaking waves on the reef edge of the east side (i.e. the breaking waves have an effect of elevating the water level).

Deducing from the tidal chart of Male', tides in the Laamu area is semi-diurnal (i.e. two high and low tides per day). The tidal range is approximately 1m during spring tide. The current regime of the causeway area is probably mainly governed by tidal and wind factors. Currents in the east side may also be influenced by the breaking waves. During the field reconnaissance no obvious strong currents were observed, except near the exit of the pipe culvert, which is inevitable since it is the only water passage between the west and east side.

4) Shoreline Erosion

The shoreline adjacent to the causeways appeared to be under erosion. Various factors may be the cause, such as global warming, tsunami, increase in severe weather, reduction of sand supply

due to less corals and so on. The causeway itself is also under continuous erosion, which is enhanced by the damage caused by the tsunami.

5) Seawater Quality

Although there are no field measurements of seawater quality in the vicinity of the causeways, obvious deterioration of water quality was observed near both causeways especially in the west side where water exchange is more limited. Furthermore, due to the tsunami, scour pits have been created on the west side, which has enhanced water stagnation. Combined with these factors, anaerobic conditions have developed in some sections of the west side, which were made obvious through the detection of hydrogen sulfide (H_2S) odor during the field reconnaissance.

6) Marine Ecosystem

Seagrass beds are densely distributed in the shallow reef flats adjacent to the causeways as shown in the photo below. The main species is *Thalassia hemprichii*.

Seagrass Bed Along the Causeway No.2

(The dense and dark patches are seagrass bed)

Patches of corals were sometimes observed near the causeway, though at very low density. Furthermore, many of the observed corals appeared to be dead, thus having very little conservation value. However, an accurate distribution of corals near the causeway is unknown.

(2) Social Environment of the Islands around the Causeways

1) Demography

The population of Gan and Fonadhoo Island is 2,244 and 1,740 respectively (as of year 2000).

2) Socio-economic Activities

Refer to Chapter 10.3.2.

3) Traffic Volume

There are no traffic count data for both causeways. However, data on the number of vehicles and

motorbikes in Gan and Fonadhoo Island was obtained through interview surveys at the Island Office, which is shown in Table 10.8.

Table 10.8 Number of Vehicles and Motorbikes in Gan and Fonadhoo Island

	Vehicle	Motorbike	Total
Gan Island	13	25	38
Fonadhoo Island	15	44	59

Source: Interview survey at Gan and Fonadhoo Island Office in May 2005

Assuming that all the vehicles and motorbikes from both islands pass the causeway once per day, the total traffic volume per day would approximately be 100. However, this figure could be a conservative estimate since it does not include the vehicles and motorbikes of the Kaddhoo Airport, fish factory in Mandhoo Island and the National Security Service (NSS) based in Kaddhoo Island.

10.4.3 Description of the Reconstruction Works

Table 10.9 shows the specification of the major works of the causeway reconstruction. The type of reconstruction work is similar with both causeways, though the scale of work is greater for Causeway No.2, due to its longer length and greater damage from tsunami. In addition, an 18m bridge will be newly installed for Causeway No.2.

Table 10.9 The Specification of the Major Works of the Reconstruction Works

	Causeway 1	Causeway 2
Excavation of the toe of the causeway	540m (270m x 2)	1,624m (812m x 2)
Dredging of sand for backfilling	2,850m^3	8,700m^3
Backfilling of core	4,050m^3	12,180m^3
Installation of geotextile sheet and armor rock	540m (270m x 2)	1,624m (812m x 2)
Pavement of road	270m	812m
Coastal protection	150m	350m
Installation of Water Passage	3 passage box culverts (0.9m x 2.6m)	5 passage box culverts (0.9m x 2.6m) 18m bridge

10.4.4 Potential Environmental Impacts

Based on the analysis of the current environmental status and the content (scale, duration, etc.) of the reconstruction projects, the following negative impacts have been identified for the construction and post-construction phase. The type of impacts are similar for Causeway No.1 and No.2, since the content of the construction activities are more or less similar. However, the magnitude of the impacts will be slightly higher for Causeway No.2 due to the longer length.

(1) Construction Phase

- Disturbance or partial loss of the adjacent seagrass bed and corals through excavation, dredging and backfilling works,
- Disturbance to the local vehicle and motorbike traffic through construction works,
- Generation of various construction related waste,

(2) Post-Construction Phase

- Deterioration of seawater and sediment quality through restriction of water exchange,
- Possible alteration of adjacent seafloor and shoreline topography through the enhanced water exchange capability of the causeway.

10.4.5 Mitigation Measures

In order to minimize the impacts on the environment various mitigation measures will be employed such as:

- Installation of silt protection curtain to minimize sediment dispersion,
- Maintenance of safe access to the causeway during the entire course of the construction,
- Installation of bridge and culverts to enhance water exchange,
- Construction of coastal protection structure to prevent shoreline erosion,
- Disposal of construction related waste in accordance to manner acceptable to the Government of Maldives.

10.4.6 Environmental Monitoring Plan

To confirm the effectiveness of the employed mitigation measures and the status of the environment, environmental monitoring will be conducted for the following parameters. The purpose of the monitoring is also described.

- Seagrass: To confirm that the construction works do not lead to any loss or disturbance to the adjacent seagrass bed.
- Corals: To confirm that the construction works do not lead to any loss or disturbance to the adjacent corals.
- SS: To confirm that the construction activities are not dispersing significant amount of sediments to the adjacent seagrass and corals.
- Water exchange: To confirm the effectiveness of the culverts and bridge in enhancing water exchange.
- Water and sediment quality: To confirm the effectiveness of the culverts and bridge in improving the deteriorated water and sediment quality near the causeway.
- Seafloor / shoreline topography: To confirm how the new culverts and bridge affects the

seafloor and shoreline topography through alteration of the local current regime.

10.5 EIA of the Upgrading of the Sewerage System in Isdhoo Island

10.5.1 Existing Status of the Sewerage System

Wastewater treatment in Isdhoo Island is currently dependant on the septic tank and soak pit system, which consist of small-scale sedimentation tanks and soak pits. However, these units are often poorly constructed and maintained. For example the sedimentation tanks are made from coral bricks or rocks, which are highly prone to leakage. Leakages from the septic tank migrate freely through the porous island soil and contaminate the groundwater. Furthermore, some tanks are too small to provide adequate retention time and settling, and as a result untreated sludge discharge directly to the soak pit and from there, to the groundwater.

10.5.2 Existing Status of Natural and Social Environment of Isdhoo Island

(1) Natural Environment of Isdhoo Island

1) Geography

Ishdhoo Island is located in the northern tip of Laamu Atoll. The Island is surrounded by a shallow reef flat with a natural lagoon in the southern side of the Island. As in all islands in Maldives the terrain of Ishdoo Island is flat and low-lying. The Island is composed primarily of reef-derived carbonate sediment that has been deposited through waves and currents.

The land area of the Island is approximately 293 hectares (MPND, 2005), which is the second largest island in Laamu Atoll. There are two villages in the Island, namely Ishdhoo and Ishdoo-Kalaidhoo. Isdhoo is located in the northern end of the island and Ishdoo-Kalaidhoo in the southern end.

Aerial Photograph of Isdhoo Island

2) Climate

Refer to Chapter 10.3.2.

3) Groundwater Quality

Groundwater aquifers in the Maldives islands normally lie between 1 and 1.5 metres below the soil surface. The proximity of the aquifers to the island surfaces makes them vulnerable to pollution and contamination from human activities and saltwater intrusion (UNEP, 2005).

Table 10.10 shows the results of groundwater quality survey conducted in Isdhoo Island in July 2005. The groundwater samples were collected from 3 wells in Ishdoo-Kalaidhoo.

Table 10.10 Results of Groundwater Quality Survey in Isdhoo-Kalaidhoo (conducted in July 2005)

	Well 1	Well 2	Well 3	WHO guideline values for drinking water
Chloride	940 mg/L	960 mg/L	1,100 mg/L	< 250 mg/L
Nitrate	0.0 mg/L	44.27 mg/L	5.31 mg/L	< 50 mg/L
Ammonia	0.42 mg/L	9.0 mg/L	11.5 mg/L	< 1.5 mg/L
Phosphate	0.21 mg/L	0.71 mg/L	0.65 mg/L	-
Salinity	2,400 mg/L	2,100 mg/L	2,200 mg/L	-
COD	14 mg/L	17 mg/L	27 mg/L	-
Total coliform	>100 / 100 ml	>100 / 100 ml	>100 / 100 ml	0
Faecal coliform	>100 / 100 ml	>100 / 100 ml	>100 / 100 ml	0

Source: JICA Study Team

The results of the groundwater quality survey are compared with the WHO guideline values of drinking water and other sources. However, since groundwater in Isdhoo is not intended for drinking water, drinking water values are used strictly for reference only. Chloride and ammonia values are substantially above the WHO guideline value in most of the sampled wells. High chloride values could be due to sewage leakage and saline intrusion. High ammonia values are most likely to be from sewage leakage.

Salinity values are also high for all the wells, exceeding 2,000 mg/L. This salinity level is not suitable for drinking even in emergency situations. The salinity values are also high for irrigation purposes except for salt tolerant crops. Salt tolerant crops can tolerate up to around 4,000 mg/L with special management (Waterwatch, 2002).

COD values are also high for all the wells, indicating high organic content. This again could be due to the leakage from the sewerage. The total coliform and faecal coliform values are substantially above acceptable levels in all locations, which is most likely to be from sewage leakage.

4) Terrestrial Ecosystem

Isdhoo Island is covered by thick vegetation especially in the mid to southern area of the Island. Species composition tends to differ with the coastal area and the interior. Pioneering species tend to habit the coastal area and longer-lived trees in the interior. The species range are limited and

mostly are abundant and widely distributed.

5) Marine Ecosystem

Inspection of aerial photograph shows dense distribution of seagrass bed in the shallow reef flat, west and east side of the Island. Seagrass beds were also observed near the island harbours, during the field reconnaissance of May 2005. The main species are probably *Thalassia hemprichii*, which is the most common species in Maldives.

Coral distribution around Isdhoo Island is uncertain.

Sea turtles are known to nest in Isdhoo Island, mainly on the beaches facing the outer atoll. The main species are hawksbill turtle (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*). However, the nesting sites appear to be under threat from severe beach erosion and littering.

(3) Social Environment

1) Demography

The population of Isdhoo Island is 1,432 as of year 2000. It is the third most populated island in Laamu Atoll. The ratio of sex is 688 males to 744 females (MPND, 2005). The number of households in Isdhoo and Ishdoo-Kalaidhoo are 184 and 130 respectively.

2) Socio-economic Activities

Fisheries and agriculture is the dominant industry in Ishdoo. In Isdhoo-Kalaidhoo agriculture is the dominant industry. Fishing is not conducted in Isdhoo-Kalaidhoo partly due to the large reef flat area, which makes it hard to access to the outer sea. The new sewerage treatment system will not have any affects on the agriculture lands.

3) Infrastructure

Table 10.11 lists the major infrastructure and facilities in Isdhoo Island. All these facilities will be connected to the new sewerage system.

Table 10.11 Major Infrastructure and Facilities in Isdhoo Island

	Isdhoo	Isdhoo-Kalaidhoo
School	1	1
Office	1	1
Mosque	4	2
Women's centre	1	1
Power house	1	1
Health centre	-	1
Island court	1	-

4) Waste Management

Isdhoo Island has a designated waste disposal site. The usual practice is then open burning at the disposal site with little segregation.

10.5.3 Description of the Project

The new sewerage treatment system will be installed in the two villages in Isdhoo Island namely, Isdhoo and Isdhoo-Kalaidhoo, and the Health Centre located in the mid-point of both villages. The major characteristics or improvements of the new system are as follows:

- Increase and improvement in the treatment process (i.e. 4 treatment steps for black water),
- Wastewater from each households will be conveyed to a common treatment facility,
- Installation of new leakage-proof septic tanks,
- no discharge to the sea, and
- no net loss of groundwater.

Construction of the new sewerage treatment system will involve the following major activities. The construction period will be approximately 8 months, starting from around November 2005 and completed around the end of May 2006.

(1) Installation of new septic tanks

A new septic tank will be installed for each household in Isdhoo (184 households) and Isdhoo-Kalaidhoo (130 households). Larger capacity septic tanks (communal type) will also be installed in the community buildings such as schools, island office and mosque.

(2) Installation of sewerage conveyance piping network for sewage water collection

Installation of an extensive network of sewage piping will be required to convey the sewage water from the home septic tanks for further treatment. The pipes will mainly be laid underground the existing roads.

(3) Construction of pump station

Fourteen pump stations will be constructed in both Isdhoo and Isdhoo-Kalaidhoo to pump the converged sewage to the 1st Mounted Leach Field. One pump station will also be constructed in the Health Centre area.

(4) Construction of 2nd Septic Tank

Seven 2nd Septic Tanks will be constructed in both Isdhoo and Isdhoo-Kalaidhoo, and one in the Health Centre area.

(5) Construction of Mounted Leach Field

Seven Mounted Leach Fields will be constructed in both Isdhoo and Isdhoo-Kalaidhoo, and one in the Health Centre area.

(6) Construction of Drying Bed for Sludge Treatment

One drying bed each will be constructed for Isdhoo and Isdhoo-Kalaidhoo. The exact location is uncertain at the moment but should be near the Health Centre area.

(7) Construction of work shop, workers camp and management office

The work shop, workers camp and management office will be constructed near the Health Centre area.

The new sewerage treatment system will require regular maintenance to keep the system functional and effective. An Operation Office will be established for this purpose. The location of the office is planned near the Health Centre area.

The main maintenance activity of the Operation Office is visual inspection of pump station, checking of clogging and regular desludging of the septic tanks, which will be conducted by vacuum truck.

10.5.4 Potential Impacts

Based on the analysis of the current environmental status and the content (scale, duration, etc.) of the projects, the following negative impacts have been identified for the construction and operation phase. The type of impacts are similar for Isdhoo and Ishdoo-Kalaidhoo since the content of the project are more or less similar.

(1) Construction Phase

1) Disturbance to the residents during installation of septic tank

There could be slight disturbance to the residents when installing the new septic tanks in their respective households. However installation works are temporary (approximately 10 days) thus impact will be negligible.

2) Disturbance to the traffic movement during installation of underground pipe

The excavation and pipe laying works involved in the pipe installation could disturb the vehicle movement. Approximately 2m width of the road will be occupied by the construction works. However, there are only 2 vehicles in Isdhoo Island and there are plenty of alternative passage ways, thus impact will be negligible.

3) Risks to public safety

The excavated grounds (approximately 1m) could be a risk to the residents. For example someone could fall into the excavated grounds, especially during night time.

4) Noise nuisance during excavation works

The road excavation works will generate noise and could become a nuisance to the nearby residents. However, since the roads are unpaved and are relatively soft, excavation works can be conducted by machinery with low noise level such as backhoe. Therefore impact will be negligible.

5) Seepage of groundwater during excavation works

During the excavation works, groundwater could seep into the excavated hole, which must be pumped out. Inappropriate discharge of the pumped groundwater then could lead to the decrease in groundwater level.

6) Clearance of vegetation

Some vegetation may have to be cleared where mounted leach field will be installed. The dimension of one leach field is 25m x 12m.

7) Generation of various construction related waste

Certain amount of construction related waste, such as construction debris (e.g. left over pipes) waste oil, domestic waste from workers and so on will be generated during the construction phase. These wastes could have adverse impact on the environment and island, without appropriate management.

(2) Operation Phase

1) Possible odor nuisance from the sludge dry beds and septic tanks

Certain level of odor will be emitted from the sludge dry beds and septic tanks and may cause some nuisance to the residents

10.5.5 Environmental Mitigation Measures

Table 10.12 shows the mitigation measures to be employed for minimizing the potential environmental impacts. Through strict enforcement of the mitigation measures, the impacts should be minimized to a negligible or minor level.

Table 10.12 Mitigation Measures against the Potential Impacts

Phase	Potential impact	Mitigation measures
Construction phase	Risks to public safety	The contractor will employ appropriate safety measures.
	Seepage of groundwater during excavation works	The pumped groundwater will be returned back to the groundwater through appropriate methods, so to prevent any net loss of groundwater.
	Clearance of vegetation	The location of the leach field will be carefully considered to minimize the loss of vegetation.
	Generation of various construction related waste	All waste generated during construction will be disposed in a manner acceptable to the Government of Maldives.
Operation phase	Possible odor nuisance from the sludge dry beds and septic tanks	The sludge dry bed will be located far from the residential area. Ventilation pipe will be installed in the septic tanks.

10.5.6 Proposed Environmental Monitoring Plan

Environmental monitoring is considered unnecessary during the construction phase of the new sewerage treatment system, due to the minor or negligible level of the impacts.

However, regular environmental monitoring of the groundwater quality should be conducted during the operation phase. The monitoring results will act as one indicator of the effectiveness of the new sewerage treatment system in improving the Ishdoo Island groundwater quality. The proposed monitoring scheme of the groundwater quality is shown in the Table 10.13.

Table 10.13 Proposed Monitoring Scheme of the Groundwater Quality

Parameters	Frequency	Location
Chloride, Nitrate, Ammonia, Phosphate, Salinity, COD, Total coliform, Faecal coliform	Once each in SW monsoon and NE monsoon season	One location each in Isdhoo, Isdhoo-Kalaidhoo and Health Centre area

10.6 Recommendations

Following are some recommendations in regards to the island harbours, causeways and sewerage projects.

(1) Island Harbours

Although reconstruction of the island harbours are extremely important for to maintain its function and the safety of the harbour users, the harbour users will experience some inconveniences during the reconstruction works, which may last for several months. To minimize these inconveniences, the contractor must fully cooperate and listen to the opinions of the harbour users and adjust their construction methods whenever possible. The harbour users must

also acknowledge the situation and cooperate as much as possible with the contractor.

During the field reconnaissance in May 2005, the Study Team has noticed various wastes such as plastic bottles, dead fish and household garbage inside some of the harbours and along the coast. Uncontrolled dumping of these wastes is aesthetically unpleasant and could also lead to water pollution. Clean up of these wastes are strongly recommended and to prevent further littering, awareness campaigns should be implemented towards the harbour users.

(2) Causeways

Reconstruction of the causeways is extremely important for the local people and industry, and must be conducted as soon as possible. Despite its urgency, consideration to the natural and social environment must also be taken since the scale of the reconstruction is large. Uncontrolled construction activities could lead to devastating impacts on the local environment. Therefore, the contractor is requested to implement appropriate mitigation measures and monitoring.

(3) Sewerage

Certain level of environmental impact is expected during the construction and operation phase, such as noise, groundwater seepage, and odor and so on. Therefore appropriate environmental mitigation measures should be employed, then all these impacts will become minor or negligible.

Maintenance during the operation phase is vital for the new sewerage treatment system to be functional and effective. With appropriate management and maintenance the sanitary conditions of the island and the local environment should gradually improve.

One of the major objectives of this project is to improve the contaminated local groundwater quality. Therefore environmental monitoring of the groundwater quality is recommended during the operation phase of the project.

CHAPTER 11 ECONOMIC AND FINANCIAL CONSIDERATIONS

11.1 Introduction

This chapter discusses medium to long-term consideration in terms of economic and financial perspectives. The country must acknowledge its position to correctly draw the future course of reconstruction and development strategy.

First, the economic situation will be compiled and analyzed, including the recovery of the major economic sector, trade and fiscal balance, and debt position. Then, preliminary economic and financial analysis will be conducted, based on which, recommendations will be made on the proposed projects on the SAPROF list. Finally, general recommendations for further reconstruction and development of the country will be made.

11.2 Present Conditions of Economy in the Maldives

11.2.1 Review of Macro Economic Performance

In general, the Maldives has enjoyed a high economic growth path in recent years under its political stability. The 2003 GDP at the market price accounted for 8,382 million Rf. or 655 million US $[1].

The economy in the Maldives is composed of the primary (9.8% of the total GDP in 2003), secondary (15.5%) and tertiary sectors (78.7%). The primary sector mainly comprises agriculture (2.6% of the total GDP in 2003) and fisheries (6.6%). The secondary consists of manufacturing (8.3%), electricity/water supply (3.6%), and construction (3.6%). The tertiary consists of wholesale/retail (4.1%), tourism (32.7%), transport/communications (14.2%), financial services (3.4%), real estate (7.5%), business services (2.9%), government administration (12.0%) and education/health/social services (1.9%). Apparently, the engine of the country's economy is tourism, and the trickle down effect leads to a growth of other sectors such as construction, wholesale and retail, and transport and telecommunications.

The annual GDP growth rate for the past several years were very high, and has never reached zero or minus. The primary sector, fisheries and agriculture, however, has lost its weight in the economy gradually. On the other hand, the secondary sector shows a steady increase in the share of the economy. The tertiary sector has remained almost unchanged for the past several years. These facts combined may indicate that the economy has been moving toward more service-oriented economy and that more labour force has been absorbed in the service industries.

[1] Ministry of Planning and National Development, *Statistical Yearbook of Maldives 2004,* pp.313-315.

The major export commodities are marine products, apparel and clothing. Marine products include fresh and chilled tuna, frozen fish, dried tuna, and canned fish. The main destinations are USA, Thailand, Sri Lanka, Japan, and UK. On the other hand, the country imports almost all products from Singapore, Sri Lanka, India, Malaysia, UAE, etc.

Looking back to the immediate past of 2004 in comparison with 2003, the following observation may be made.[2]

Macroeconomic developments in the domestic economy continued to accelerate during 2004. According to estimates released in mid December 2004, a real economic growth accelerated to 8.8 % during 2004, after a growth of 8.4 % in 2003, largely owing to the growth in the tourism and construction sectors.

The tourism sector is the major source of fiscal revenue and foreign exchange earnings into the country. During 2004 the sector accounted for 34 % of GDP. The number of tourists who visited the country registered more than 9 % increase at the end of 2004, totaling 616.7 thousand tourists. Similarly, tourist bed nights also recorded an increase of 9 % during 2004. The total number of beds in the tourist resorts was (on average) less by 58 beds against 2003, while the number of resorts in the country remained at 87 as in the previous year. Meanwhile, the average annual capacity utilization rate rose to 84 % in 2004 compared to 77.2 % in 2003.

The fisheries sector remains important to the country's economy both in terms of employment and exports. The value added to the sector is estimated to have registered 2 % in 2004, with the total fish catch registering 148.5 thousand metric tones during the year. Meanwhile, earnings from fish exports registered a 22 % increase in 2004, while the volume increased by 8 % with the frozen tuna comprising 77 % of total fish export volume and registering 11 % growth during the year. Meanwhile, the total volume of canned fish and dried fish exports (each accounting for around 10 percent of total fish exports) increased by 2 %, while earnings from these products increased by 10 % and 7 % registering 13.4 million US$ and 11.6 million US$ respectively.

The expansion in the tourism sector has meant that transport and communication activities have increased significantly in recent years, with the sector contributing to about 15 % of GDP in 2004 and registering an annual growth of 13 % during the year. The construction sector also grew in 2004 by 28 % with developments by both the private and public sectors. The wholesale and retail trade contributed to around 4 % of GDP and grew by 5.4 % in 2004 after a 4.3 % growth in 2003, reflecting the positive developments in the tourism, fisheries and construction sectors.

[2] The following is a summary of *Overview of Economic Developments During 2004*, based on the information as of 20th April 2005 by Maldives Monetary Authority (http://www.mma.gov.mv/red.php)

With reference to the domestic price developments**,** with the rise in oil prices as well as domestic fish prices during the year, the inflation rate (measured in terms of changes in Consumer Price Index, excluding food) stood at 3.9 % in 2004 following a negative 2.5 % in 2003.

The total employment in the economy stood at 86,245 according to the 2000 census, which was a 29 %t increase from the 1995 census. At the end of 2004, the total public-sector employment stood at 26,242 and increased by about 8 % from 2003. In the private sector, demand continued to be high in the labour market. While detailed employment statistics are not available on an annual basis, expatriate employment data indicates that the number of foreign workers in the country increased from an average of 32,459 workers in 2003 to 36,116 workers in 2004, reflecting an 11 % increase during the period. Of such workers, 27 % were employed in the tourism sector, 20 % in construction, 12% in the business activities sector, and 7 %uction industry.

On the fiscal front, the overall budget deficit declined from 3 % of GDP in 2003 to 2 % of GDP during 2004. The total revenue grew by 12 % during the year, reflecting the favorable economic developments. Of the tax revenue the tourism tax increased by 15 % while the import duty increased by 38 %. Meanwhile grants received during year 2004 continued the declining trend. On the expenditure side, growth in total expenditure and net lending moderated to 5 percent in 2004, after registering a growth of 9 % in 2003. Current expenditure, accounting for 75 % of total expenditure and net lending, grew at an annual rate of 13 % in 2004 while capital expenditure declined by 9%, largely reflecting the winding down of some key infrastructure projects in 2003 including the first phase of the Hulhumalé Development project. About 51 % of current expenditure and 36 % of capital expenditure during 2004 were spent on social services, while economic services accounted for 6 % of current expenditure and 40 % of capital expenditure. The budget deficit narrowed by 43 % during 2004 from 300.3 million Rf. in 2003 to 170.1 million Rf. in 2004. As in 2003, the deficit was financed entirely by foreign project assistance.

On the monetary accounts, total domestic credit of the banking system reached record high levels during 2004 having increased by 32 %. This was largely due to the high growth in credit offered to the private sector by commercial banks, which registered 58 % increase during the year following a 7 % growth in 2003. Of the credit extended to the private sector, 58 % was extended to tourism, 21 % to commerce and 7 % and 6 % to agriculture and fisheries sectors respectively. Credit to the public sector, meanwhile, declined by 26 % during the year. With the favorable developments in the economy, the net foreign assets of the banking system also registered an improvement of 29 % with rapid increases in the foreign assets of the Maldives Monetary Authority or MMA (27 %) as well as the commercial banks (30 percent). Consequently, the dollarization ratio (ratio of foreign currency deposits to broad money) stood at 55.5 % at the end of 2004 compared to 51 % at the end of 2003. As a result of these developments, total liquidity of the banking system increased by 33 % during the year.

According to balance of payments estimates in December 2004, the current account deficit worsened in 2004, largely on account of the estimated 31 % growth in merchandise imports while merchandise exports increased by 13 % during the year. However, the net service inflows are estimated to have increased by 22 % during 2004, with around 19 % growth in tourism receipts. Owing to the large amount of remittances by the expatriate labour force working in the country during the year, the transfer account continued to register a deficit. In the capital account, official flows reflected a decline of 19 %t; however, with significant private sector investment activities during the year, private capital flows are estimated to have increased during the year. The overall balance of payments was positive in 2004 resulting in a strengthening of the gross international reserve position during the year. However, given the large increase in imports, reserves in terms of import cover was estimated to be equivalent to 3.8 months of imports at the end of December 2004, as opposed to 4.1 months at the end of December 2003.

As regards to the exchange rate, the Maldives continued to maintain a pegged exchange rate, with the Rufiyaa pegged to the US dollar at a mid rate of 12.80 Rf. per US$, with a spread of 10 Laaris between the buying and selling rates. As a result, the Rufiyaa depreciated against most foreign currencies during the year along with the weakening of the US dollar.

11.2.2 Social and Other Dimension

The Maldives can be regarded as a politically- and socially-stable country if compared with other developing countries. And it has enjoyed its fruit of high economic growth for the past decades.

The government administration system is well organized and well coordinated among ministries and organizations. The government ministry is rather small, due to the size of the country, but efficient, and the staff is relatively young, well trained and well motivated. In fact, a consensus of donors long dealing with the government officials is that the Maldives is ranked high in terms of governance.

The country is active in the international arena with diplomatic relation to more than 130 countries. It became a member of UN at the time of independence in 1965. It became a member of the World Bank and IMF in 1978, and a member of South Asian Association for Regional Cooperation (SAARC) or an organization of regional cooperation in South Asia in 1985. It also holds a membership of the Commonwealth, the Colombo Plan, the Asian Development Bank (ADB), and the Islamic Development Bank (IDB).

In connection with UN, in December 2004 the country has been recommended to graduate from the category of LDC or low developing countries with the transition period of three years[3]. This implies that the country will rely on less grant and more loans from now on.

[3] This was made before tsunami so there will be a discussion on this: delaying the implementation or not.

Socially, the country has several unique features.

- The country has a long history so the people of the country have several origins, but nowadays is considered as Maldivians in total.
- The official language is Dhivehi, but English is widely spoken and used including the government document.
- The islands and the population are widely spread, so the economic and social gap between the capital and the islands in the atoll, or the urban and the rural areas remains large since the independence to date.
- The country divides itself into two: the resident islands and the resort islands. The latter is exclusively kept for international tourists, and the former for the nationals.

The Maldives may be regarded as a young country since more than one-third of the population is between 16 and 35 years of age. Although the population growth rate has come down quickly to 1.9% in 2000, the government must find places for work and places to live for the young generations, who are moving to the urban areas.

The Maldives has a high literacy rate and is very enthusiastic about higher education. Due to the recent development of ICT (Information and Communication Technology), the people can gain access to ICT devices such as cable and satellite TV, mobile telephone and internet. Exposure to foreign contemporary culture and world daily news is changing the life style of younger generations from traditional way of life and value of their parents to “internationalized” way.

At the moment the labour market has a large gap between demand and supply of labour force. This gap is filled with foreign labour of more than 30,000 (2002). The occupation varies from workers to professionals such as doctors and teachers. On the other hand, it is said that 30,000 young people after school will look for jobs for several years to come. But it is apparent they can not immediately take over the jobs which foreign workers do, thus, it is feared that unemployment or half-employment may become a social issue, which may have to be solved by the entire government sector in the years to come.

11.2.3 Impact of Tsunami

The tsunami had a major macroeconomic impact, much of which will become gradually realised over the year of 2005 and later. The immediate estimate said that 470 million US$ or more than half of the GDP worth damage had been made[4]. This does not include indirect effects such as decrease in tourist arrival. The anticipated effects in 2005 include: a significant weakening in

[4] *The Joint Need Assessment*, The World Bank, ADB and UN, February 2005, and MPND, *National Recovery and Reconstruction Plan*, March 2005

economic performance, with low real GDP growth (estimated at from 5-6% to 1 %[5]), a larger current account deficit, and a widening of the fiscal deficit. The employment has been adversely affected by the tourism downturn, the loss of fishing vessels and equipment, etc.

Especially, tsunami hit the high season of tourism so that decrease in tourism must adversely affect commerce, restaurants, transport, and telecommunications as well. Thus, some estimated that a loss of tourism revenues and fisheries exports amount to 160 million US$.

On Impact to Poverty

The country is not categorized into HIPCs or highly indebted poor countries. The World Bank-led PRSP or poverty reduction strategy paper was drafted in 1997 and the targets on the paper were already met till today[6]. For instance, before tsunami, the share of the absolute poverty of 15 Rf. and less per day was down from 43 % of the population in 1997 to 22% in 2004[7]. This is mainly due to the high economic growth of the past 25 years and the government policies toward the atoll development.

Although we do not have concrete figures at hand, it is feared that the number of absolute poverty has increased after tsunami, in particular in the atoll area. 39 islands were affected, 14 severely damaged, 100,000 affected in total, 12,000 people left the residential islands, and 8,500 left home and evacuated in the island. Apparently, tsunami hit more on people with poverty.

Recovery and reconstruction efforts are now being made toward islands people, hence, toward this poverty group.

11.2.4 Future Course of the Economy

The impact of the tsunami on economic growth will depend largely on the evolution of the tourism. As of July 2005, there are indications that tourist arrivals may be rebounding more quickly than previously anticipated. Table 11.2[8] shows figures of tourist arrival, bed nights, bed capacity and occupancy rate in comparison of 2004 and 2005.

The first six-month of the year 2005 recorded a little more than half of the arrival in compared with the same period of 2004. However, it is worth noting that every new month was better than the previous month in terms of number of arrivals. The same holds for bed nights for the resort. And it holds for the occupancy rates for the resort as well. However, the bed capacity of the resort has been down by 20%, and has not yet fully recovered. It is encouraging to find that the average

[5] IMF, *Maldives Use of Fund Resources---Request for Emergency Assistance*, February 2005
[6] Ministry of Finance and Treasury is responsible for this, and commented so.
[7] Comment from the security and livelihood economist of the World Bank monitoring poverty situation.
[8] In the Table2, the frontier arrival means arrival by air. The figures are classified into two: resorts and hotels. As figures show, the recovery of hotels is quicker than that of resorts since the donor teams visited and stayed in the hotel. The stay by donor teams may have contributed to the average stay of 8 days during the initial three-month or so.

duration of the stay is above 8 days in the first six-month of 2005, and is unchanged with 2004. In fact, most of the resorts did not sustain damages, and themselves had already repaired many of the damaged resorts to date. The government of Maldives expects bed night capacity to recover to almost 100 % by the end of 2005. Moreover, provided that the tourists keep coming back and the number of bed capacity at the resorts is constantly increasing, the tourism income will no doubt increase and pull the growth of other sectors as well.

The government will have a constant revenue sources as ever and even there is some more room for raising the bed tax from the present 8 US$ a day per head to higher rate in the coming future.

Possible risks

The largest bottleneck, if any, will be a shortage of manpower fitted to a particular vacancy, which may be filled by the foreign skilled labour as is done at present.

In the short run, there will be a so-called reconstruction demand for the tsunami-hit infrastructure. The consumer price may rise[9], and more domestic labour is employed. However, after the reconstruction stage of three to five years, there will be expected to have a backlash, though small, not large, to the economy.

The declining demand for construction, commerce and transport sectors may incur a short-period stagnation to the economy. Despite the after-reconstruction effect, the economy will show again the positive growth due to the relatively large share of tourism to the economy in the years to come.

[9] IMF projected increase in CPI to become 6.8 % in 2005, but back to as usual as 2.8 % in 2006.

Table 11.1 Major Economic Indicators

	Actual									Estimate	Projection					
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Macro Indicators																
GDP(US$mil)	400.5	450.4	508.2	540.1	589.2	624.3	625.1	640.7	690.8	753.1	828.4					
Real Growth Rate	7.8	9.1	10.4	9.8	7.2	4.8	3.4	6.5	8.4	9.0	1.0	9.0	6.0	6.5	7.0	7.0
CPI (Inflation, %)	5.5	6.2	7.6	-1.4	3.0	-1.2	0.7	0.9	-2.9	6.4	6.8	2.8	2.5	2.5	2.5	2.5
Interest Rate (%)							5.5	3.5	3.0	2.5						
Exchange rate (Rf/$)	11.77	11.77	11.77	11.77	11.77	11.77	12.24	12.80	12.80	12.80						
GDP pc (US$)		1,800	1,989	2,071	2,214	2,300	2,265	2,284	2,423	2,603	2,779					
Fiscal Indicators																
Fiscal balance	-25.5	-19.0	-6.9	-10.5	-23.9	-27.4	-29.7	-32.9	-36.5	-33.5						
Revenues (US$mil)	119.7	133.2	155.0	164.0	189.1	201.5	206.1	212.1	239.2	254.7						
Expenditures(US$mil)	145.2	152.2	161.9	174.5	212.9	228.9	235.8	245.0	275.7	288.2						
BP Indicators																
Trade Balance (US$mil)	-150.8	-185.6	-217.3	-215.9	-262.4	-233.3	-236.0	-212.4	-262.3	-368.8	-498.7	-467.9	-492.6	-487.1	-530.6	-581.7
Exports(US$mil)	85.0	79.9	89.7	95.6	91.5	108.7	110.2	132.3	151.9	172.7	131.0					
Imports(US$mil)	-235.8	-265.5	-307.0	-311.5	-353.9	-342.0	-346.3	-344.7	-414.3	-541.5	-609.8					
Non-trade Balance(US$mil)	156.1	201.1	218.0	232.4	234.6	238.8	244.2	251.7	311.1	375.5	234.8	376.0	437.1	506.8	593.0	691.9
Public Capital Balance(US$mil)	24.8	17.3	6.6	14.6	5.2	-1.9	7.8	26.8	33.8	27.2	40.0					
Private Capital Balance(US$mil)	33.6	41.0	42.9	42.9	42.9	25.6	24.3	33.9	56.8	71.6	80.0					
Statistical Errors(US$mil)	-24.9	-7.1	12.6	-6.6	23.6	19.9	5.2	14.9	15.5	16.0						
Overall Balance(US$mil)	15.3	43.7	27.4	29.1	-7.2	-7.9	-21.4	39.8	74.3	24.5	-67.8					
GDP raitio																
Fiscal Deficit(%)	6.4	4.2	1.4	1.9	4.1	4.4	4.8	5.1	5.1	4.2						
Trade Deficit(%)	37.7	41.2	42.8	40.0	44.5	37.4	37.8	33.2	36.7	35.1						
Foreign Currency Reserves(US$mil)	49.3	77.6	99.7	119.9	128.5	124.1	94.3	134.5	161.0	205.1	205.1	208.8	236.1	240.7	266.1	323.9
Debts (DT)																
External Debts (US$mil)	172.2	177.2	178.1	200.8	212.9	211.6	209.8	259.0	280.9	316.6	395.5	482.0	563.8	610.9	646.8	678.7
Medium/long term Debts(US$mil)	151.6	163.7	165.3	184.7	185.6	178.0	181.3	223.1	264.3							
Public External Debt(US$mil)	127.8	132.3	135.2	144.0	143.7	139.4	141.3	164.7	184.3							
External Commercial Debts(US$mil)	23.8	31.4	30.1	40.7	41.9	38.6	40.0	58.4	80.0							
Short-term Debts(US$mil))	20.6	13.5	12.8	16.1	27.3	33.6	28.3	35.9	16.6							
Debt Service Ratio(%)	3.4	3.2	6.9	3.8	4.4	4.8	4.8	4.6	4.0	4.1	5.9	5.0	4.6	4.5	4.3	4.1
Increase in Debts(%)		2.9	0.5	12.7	6.0	-0.6	-0.9	23.6	8.5	7.5						

Source：Ministry of Finance and Treasury, Ministry of Planning and National Development、Maldives Monetary Authority

Note: Figures of 2004 is an estimate and figures from 2005 onward is estimated by IMF.

Table 11.2 Tourist Arrival after Tsunami

	year	January	February	March	April	May	June	Jan-June
tourist arrival								total
frontier arrival	2004	61,861	59,692	63,855	55,396	42,197	33,832	316,833
	2005	18,747	29,391	35,742	29,714	25,309	22,590	161,493
	growth%	-69.7	-50.8	-44.0	-46.4	-40.0	-33.2	-49.0
surface arrival	2004	542	79	2,857	152	9	19	3,658
	2005	793	724	843	281	12	25	2,678
	growth%	46.3	816.5	-70.5	84.9	33.3	31.6	-26.8

bed nights								total
resorts	2004	508,856	481,891	501,334	454,443	345,775	270,056	2,562,355
	2005	125,919	228,722	297,864	250,832	213,420	180,148	1,296,905
	growth%	-75.3	-52.5	-40.6	-44.8	-38.3	-33.3	-49.4
hotels	2004	13,311	11,547	11,305	9,312	8,235	7,254	60,964
	2005	9,664	8,843	8,992	8,512	7,609	6,756	50,376
	growth%	-27.4	-23.4	-20.5	-8.6	-7.6	-6.9	-17.4
total	2004	522,167	493,438	512,639	463,755	354,010	277,310	2,623,319
	2005	135,583	237,565	306,856	259,344	221,029	186,904	1,347,281
	growth%	-74.0	-51.9	-40.1	-44.1	-37.6	-32.6	-48.6

bed capacity								average
resorts	2004	16,088	16,212	16,252	16,422	16,168	15,468	16,102
	2005	12,788	12,440	12,802	13,322	13,038	12,814	12,867
	growth%	-20.5	-23.3	-21.2	-18.9	-19.4	-17.2	-20.1
hotels	2004	670	670	636	636	636	636	647
	2005	636	636	636	636	636	636	636
	growth%	-5.1	-5.1	0.0	0.0	0.0	0.0	-1.8
total	2004	16,758	16,882	16,888	17,058	16,804	16,104	16749
	2005	13,424	13,076	13,438	13,958	13,674	13,450	13503
	growth%	-19.9	-22.5	-20.4	-18.2	-18.6	-16.5	-19.4

occupancy rate(%)								average
resorts	2004	102	106.2	99.5	92.2	69	58.2	93.8
	2005	31.8	63.4	75.1	62.8	52.8	46.9	57.2
	change	-70.2	-42.8	-24.4	-29.4	-16.2	-11.3	-36.6
hotels	2004	64.1	61.6	57.3	48.8	41.8	38	54.7
	2005	49	47.9	45.6	44.6	38.6	35.4	45.1
	change	-15.1	-13.7	-11.7	-4.2	-3.2	-2.6	-9.6
total	2004	100.5	100.8	97.9	90.6	68	57.4	85.9
	2005	32.6	64.9	73.7	61.9	52.1	46.3	55.3
	change	-67.9	-35.9	-24.2	-28.7	-15.9	-11.1	-30.6
average duration of stay(days)	2004	8.4	8.3	8	8.4	8.4	8.2	8.3
	2005	7.2	8.1	8.6	8.7	8.7	8.3	8.3
	change	-1.2	-0.2	0.6	0.3	0.3	0.1	0.0

Source: Statisitics Section, Ministry of Tourism, as of July 2005

11.3 Preliminary Economic and Financial Analysis

11.3.1 National Development Plan

At the on-going Sixth National Development Plan 2001-2005[10], the followings are in focus.

(1) Economy

In the economic sphere, diversification of the economy is the key. In the fisheries sector, fishing efforts shall be made not only on traditional tuna/skipjack, but also on exotic reef fish species. Maintaining the quality of fish products is another importance so that the time of transport catch to the nearby landing site is critical. When establishing a fish processing plant, transport from the catch to landings must be speedy. To promote local indigenous fishing, landing facilities like small jetties and ports are no doubt important as well. To promote local agriculture, transport time between suppliers and markets is very important. Likewise, to develop local food processing industries, the means to transport the product to the major market is indispensable.

(2) Infrastructure

The country aims at a comprehensive sea and sky network connecting all atolls. Thus, rehabilitating the transport facilities must contribute to fostering economic and social development in growth centers, and must be in line with the on-going National Transport Development Plan. At the Plan, a National Transport Master Plan is supposed to be formulated. The Plan would include:

- The development of a transport grid involving air, sea and land transport services
- The development of international airports to integrate and sustain activities in the larger national arena
- The development of Male commercial harbor and the regional ports to cater to the development needs of the country
- The development of inter-island transport networks by air and sea with special emphasis on realizing synergies
- The development of sustainable and efficient intra-island transport networks, taking into consideration the increasing demand for motor vehicles, sea-based vessels and pollution
- The harmonization of transport system with the growth of the tourism sector

In line with this policy, the government would invite private sectors.

- Develop the transport grid as a viable and profitable business venture with involving the private sector. The approach is necessary to increase private sector participation in the economy, promote economic diversification, and for the grid to be sustainable in the long run.

[10] MPND, *Six National Development Plan 2001-2005*, second edition (reprint), 2004

- Develop the grid as a network of individual operators who can manage their own operations by sea, air, land or mixed, to serve niche markets.

Water and sanitation is another importance at the infrastructure aspect. The Plan states to provide adequate water supply, sanitation, and safe and environmentally sound management of sewerage and solid waste disposal facilities to all islands with the strategies as follows.

- Formulate a plan to provide safe water, sanitation, and waste disposal to all islands with defined needs and priority actions.
- Develop a national waste management strategy and facilitate its enforcement.
- Encourage and facilitate private sector to become more involved in providing sanitation and wastewater management services.
- Promote the inclusions of sanitation issues not only in planning health services but also in planning and provision of education, infrastructure development and construction activities.
- Promote land use planning to protect fresh water aquifers.
- Continue to raise awareness regarding personal hygiene and good sanitation practices, including the safe use of latrines.
- Continue to raise awareness on solid waste management
- Promote use of cleaner technologies and encourage safe use and disposal of hazardous materials.
- Identify, and promote sustainable systems that are appropriate for small islands for water production and distribution, sanitation and waste management.
- Develop and enforce guidelines and operational procedures for sewerage projects.

(3) Social Aspect

Of course, the *Vision 2020* pronounces equitable access of all the people to basic utilities and services such as education, health care, potable drinking water, electricity and essential consumer goods. In order to do so, the means of transport at minimum level covering all the atolls is necessary. Providing all islands with the basic infrastructure for the development of social and income generating activities is a must.

From July to October 2005, Ministry of Planning and National Development will review the on-going Plan together with the ADB consultants, and based upon that and adding the tsunami reconstruction, it will make a new Seventh National Development Plan 2006-2010 toward the end of this year, 2005. It will not be an easy task to review the achievement of the planned targets since the targets in the Sixth Plan are not quantified and the unexpected negative impact of tsunami is given. However, considering that the poverty is more severe in atolls and that the atolls were more hit by tsunami, it is certain that more weight shall be given to atoll development, social and economic, at the coming Seventh Plan.

11.3.2 Atolls Situation

(1) Two Atolls before Tsunami

Laamu Atoll with a population of 11,588 (as of 2000 Census) has 12 inhabited islands[11]. Fonadhoo Island with a population of 1,740 is the capital island, where there are diversity of industries such as agriculture, business, masonry, retail shops, fast food shops and pharmacy. The largest island is Gan, having a land area of 516.6 hectares and population of 2,244. Isdhoo Island with a population of 1,432 is where sewerage system may be planned. The other islands have very similar characteristics: small number of population with indigenous fishing. Lammu Atoll has an airport in Kaddhoo, which connects to Male' in 45 minutes flight.

Thaa Atoll has a population of 9,305. The capital island is Veymandhoo with a population of 763. Agriculture, carpentry, small business and masonry are the main industry in this island. Vilufushi Island with a population of 1,155, has a variety of industries such as shipping, rope making, sewing, thatch weaving, carpentry, and masonry. Dhiyamigili Island with a population of 484 has rope making, masonry, carpentry, shipping, and agriculture. Hirilandhoo Island with a population of 759 has sewing, small business and boat building. Guraidhoo Island with a population of 1,433 has small business, shipping in addition to fishing. The other islands have more or less similar characters: the economic activities are more or less centred around indigenous fishing.

The two Atolls seldom have employment in hotels and restaurants since they do not have any resorts[12]. They are engaged in fishing (2 persons out of 10 labour force), community and social services (2 out of 10) and manufacturing (1.5 out of 10).

In summary, these two Atolls show the character of typical non-resort atolls, though Laamu Atoll has potentials for resorts. Also there is good room for fisheries and agriculture development catering for the in-atoll resort. There may be a potential in Thaa Atoll as well. In fact these two atolls are important in terms of development policy of the country. Vilufushi Island of Thaa Atoll is a first priority –safe and host island. Gan of Laamu is a first priority -safe and host island.

During the course of the 6th National Development Plan, some progress was made to minimize diseconomy of scale through resettlement of small communities in small islands to larger islands that can provide public services at a reasonable cost. Although this task is admittedly politically sensitive and has to be handled with considerable caution and care[13], things must be going on in a continuous manner. In this context, development of two atolls is among the top priorities.

(2) Tsunami Damage to Two Atolls[14]

Apparently, the area was one of the most extensively damaged by the tsunami. Thaa Atoll of 8,513 populations in mid-2004 recorded 16 deaths and 3 missing, and 563 damaged buildings.

[11] Information obtained from the web site of Ministry of Atoll Development
[12] The one resort will be open in 2005 at the Laamu Atoll.
[13] MPND, *6th NDP 2001-2005*, p.3
[14] The information for this section is from the web site of Maldives Disaster Management Center, MDMC.

Laamu Atoll of 11,318 population recorded 22 deaths and 3 missing, and 285 damaged buildings. At the national level of 270,101 populations, 82 deaths, 26 missing, and 3997 building damage were recorded. Therefore, the share of Thaa Atoll on human casualty was 18% of the country, and Laamu, 23%. The share of physical damage was 14% and 7%, respectively. So the two atolls were among the most-hit atolls, especially in terms of human casualty.

Besides, 5 islands do not have unusable administration facilities in the Thaa, and 3 islands do not have unusable administration facilities in the Laamu. In addition, two atolls have considerable damages to the mosques, schools, health posts and beaches.

It is not an easy task to estimate the damage of the two atolls in terms of value. To obtain some idea on the damage made to the two atolls, we have made make several assumptions.

- The damage to house is relatively well compiled, which will be employed to get an extent of the total damage in all sectors.
- The total damage assessment of 197.9 million dollars, is based on the National Recovery and Reconstruction Plan (NRRP) in March. However, the damage to tourism is not counted. Indirect damage is not counted, either.
- We also assume that the damage to all sector is proportional to that to housing sector, since the community comprises not only from houses, but also roads, ports, schools, health posts, water and sanitation facilities, fishing vessels, electric power generators, etc.

The damage is estimated at 42 million dollars for Laamu Atoll, and 28 million dollars for Thaa Atoll. The percentage is 21.5 % and 14.2 %, respectively (refer to Table 11.3).

Table11.3 Damage Estimated by Atoll

	Population (mid 2004)	Buildings damaged	Damage in percent	Gross damage in value (million US$)	Order in damage
National	270,101	5,207	100%	197.9	
Atolls					
Haa Alif	13,733	94	1.8%	3.57	
Haa Dhaal	17,141	86	1.7%	3.27	
Shaviyani	11,807	276	5.3%	10.49	6
Noonu	10,044	206	4.0%	7.83	
Raa	15,331	693	13.3%	26.34	3
Baa	9,344	78	1.5%	2.96	
Lhaviyani	8,158	77	1.5%	2.93	
Kaaf	8,458	276	5.3%	10.49	6
Alif Alif	4,995	93	1.8%	3.53	
Alif Dhaal	7,063	27	0.5%	1.03	
Vaavu	1,580	156	3.0%	5.93	
Meemu	4,845	567	10.9%	21.55	5
Faafu	3,864	0	0.0%	0.00	
Dhaalu	4,939	569	10.9%	21.63	4
Thaa	8,513	741	14.2%	28.16	2
Laamu	11,318	1118	21.5%	42.49	1
Gaaf Alif	8,187	123	2.4%	4.67	
Gaaf Dhaal	10,505	27	0.5%	1.03	
Gnaviyani	7,645	0	0.0%	0.00	
Seenu	17,980	0	0.0%	0.00	

Note: The Study Team estimated from data of MDMC as of April, and TRRF, as of March, 2005. Since there were no official figures of damage value by atoll, we used the percent of building damages as that of the total damage in each atoll.

(3) Challenge after Reconstruction

Owing to the on-going reconstruction effort, re-building houses will be moving, and debris is being removed from the residential center. Internally displaced people (IDP) will return to the original places or move to new sites within several years.

However, in the long run, the area has a serious challenge, that is, how to sustain the reconstruction and development by themselves. Thus, we may need a regional development plan, which may include the following elements:

1. Development of near-by resorts, which can absorb the local workforce, and the resort can be a major market for various local products.
2. Development of high-quality fisheries and agricultural products catering for such resorts.
3. Development of major industries includes fisheries, tourism, and agriculture, which may sustain even after the tsunami recovery, not necessarily to depend on the public works.

The biggest issue of the Atolls is scarcity of employment opportunity. There are no major industries to absorb the large numbers of young population except for the fish factories.

(4) Impact of the Proposed Projects

The economic impact of the proposed harbor projects in the Laamu and Thaa Atolls are as follows:

1. The residents of each Atoll can commute to the public facilities, such as school or work places at lower cost and less time.
2. The commodities can be transported in and out with much ease and less expenses.
3. The harbor will have more front landing space, thus the handling capacity will increase.
4. The fishing vessels will be more active by utilizing the rehabilitated harbor.
5. The external assistance, if continues, can be easily accessed to the damaged site.
6. The last but not the least, future disasters can be contained with the rehabilitated harbor and other facilities.

The following indirect but positive effects to the atolls are worth consideration. With rehabilitated infrastructure, two atolls, by making a full use of closeness to the Kadhoo airport, which is only a 45-minute flight from the capital Male', may be able to further develop resorts and resort-related sectors such as agriculture, handicrafts, etc.

In case of the sanitation projects in the Isdhoo Island in Laamu, the following direct and indirect impacts can be expected:

1. The people can live in more hygienic living environment.
2. The surrounding natural environment will be kept clean.
3. This can be a model project for the entire country since the concern over sanitation surely will have to be needed to tourism-led countries like Maldives in the future.

In case of sanitation, greater care for the operation and maintenance will be required compared to the harbor reconstruction. Therefore institutional and organizational arrangement might be necessary together with the so-called hard-infrastructure.

11.3.3 Project Selection Criteria for SAPROF

The SAPROF team has proposed a list of subprojects to be implemented with the counterpart of the government.

The general criteria [15]are as follows.

[15] For this section, the following is a reference document: ADB, *Report and Recommendation of the President to the Board of Directors on a Proposed Loan and Grant to the Republic of Maldives for the Tsunami Emergency Assistance Project*, March 2005.

1. The subproject rehabilitates or restores damaged infrastructure and facilities caused by the tsunami.
2. The subproject is technically feasible, cost-effective, and represents a least-cost alternative.
3. The subproject incorporates beneficiary consultation.
4. The subproject shall be completed within the reconstruction period of three years.
5. Another agency or the government does not finance the subproject.
6. The subproject is prioritized on the basis of their social and economic direct impact.
7. The subproject is in compliance with the government environmental requirements, and JBIC environmental guidelines.
8. The subproject is not expected to involve any involuntary resettlement.

Moreover, the criteria to select sewerage projects are as follows.

1. Consultation with affected communities
2. Providing opportunities for local community participation in reconstruction works, and further involvement in operation and maintenance

The criteria for the selection of the port projects are as follows.

1. Providing short-term reestablishment of public services
2. Contributing significantly to reconstruction operations
3. Contributing significantly to reestablishment of safety in economic operations including fishing, maritime transport and tourism
4. Providing opportunities for local community participation in reconstruction works

11.3.4 Candidate Projects

The SAPROF team composed of port and sewerage engineers, has compiled in late June the list of sewerage and port projects, which may be JBIC-financed[16]. The sewerage and port projects are all in line with the criteria, and requested by the government as of May 2005.

Donor coordination

When selecting candidates, one more consideration is on donor coordination. The list proposes 13 harbor projects plus Male', and 9 sewerage projects.

The list of harbors fills in the 5 gaps, implying that Japanese side has largely met the needs of Maldivian side. Four projects are supposed to implement by Japan NPGA. According to Table 11.4 as of May 2005, a harbor project at the Hinnavaru is supposed to implement by UNDP. However, it is reasonably assumed that the donor has been changed afterward. There are a few donors,

[16] This list may be re-assessed in the future course of events by the government and JBIC headquarters.

which are committed to the sewerage sector.

From donor coordination points of view, it seems well coordinated to the islands of heavy damage. For instance, at the Filladhoo Island, HA, UNICEF does primary school, GRC does health, the government does housing, IFRC does water, and Japan does sewerage.

Table 11.4 Donor Projects by Atoll

SAPROF	Atoll	Island	Primary School	Health Physical Facilities (Rf)	Health Equipment and Furniture (Rf)	Health Consumables (Rf)	Housing Repair	Housing Reconst.	Diesel. Plant	Water Collection/ Distribution	Sewerage	Jetty	Harbour	Livelihood	Community Centre	Island Office
S	HA	DHIDHDHOO		-	-	-	Japan NPGA / GoM	-		IFRC		-	Gap			
S	HA	Filladhoo	UNICEF	Gap (HP)	GRC (HP) 269,532.91	GRC	Japan NPGA / GoM	GoM	UNICEF	IFRC		-	-			
S	HA	Baarah		-	-	-	Japan NPGA / GoM	GoM		IFRC		-	-			
S	HDh	Nolhivaranfaru	UNICEF	-	-	-	GoM	GoM		IFRC		Turkey	-			
H	HDh	Makunudhoo		-	-	-	-	-		-		-	Gap			
H	Sh	Maaugoodhoo		-	-	-	-	-		-		-	-			
S,H	Sh	F0NADHOO		-	-	-	-	-		-		-	Gap			
H	N	Lhohi		-	-	-	-	-		-		-	-			
S	N	MANADHOO		-	-	-	-	-		-		-	Gap			
H	Lh	Hinnavaru		-	-	-	Japan NPGA / GoM	GoM	Singapore Govt.	IFRC		UNDP	UNDP			
H	B	Thulhaadhoo		-	-	-	-	-	UNICEF	-		Gap	Gap			
S	B	EYDHAFUSHI		Gap?	Gap?	Gap?	UN (ECHO)	UN (ECHO)	UNICEF	IFRC		UNDP	UNDP			
H	K	Maafushi	UNICEF (E&T Centre)	GoM	Gap	WHO	UN / GoM	IFRC		IFRC	IFRC	-	Gap			
H	Th	Hirilandhoo		Gap (HP)	Gap	WHO	-	-		-		-	Japan NPGA			
H	Th	Guraidhoo		-	-	-	Japan NPGA / GoM	-	UNICEF	IFRC		Japan NPGA	Japan NPGA			
S	ADh	Maamigili		-	-	-	-	-		-		-	-			
S	M	Muli	UNICEF	GRC (RH) 19,968,222.92	GRC	GRC	UN	UN	OXFAM	IFRC		-	UNDP?		HPL Singapore?	
H	L	Isdhoo-Kalaidhoo	UNICEF	Gap (HC)	UNFPA	UNFPA	Japan NPGA / GoM	BRC	UNICEF	IFRC	JNPGA	-	Japan NPGA	BRC		
H	L	Kalhaidhoo	UNICEF	Gap (HP)	Gap	WHO	-	-		NR/ New house		-	-			
H	L	Fonadhoo		-	-	-	Japan NPGA / GoM	BRC		IFRC	JNPGA	-	Japan NPGA	BRC		JNPGA
H	GA	Dhaandhoo	UNICEF	-	-	-	Japan NPGA / GoM	UN	UNICEF	IFRC		-	Gap			

Note: The original matrix was provided by MPND as of May 2005. The sector, which has blank column, is removed from the original table. The capital Male is removed as well. S stands for sewerage project, and H stands for harbor project of SAPROF.

11.3.5 Debt Sustainability

(1) Statistics

Statistics on external debt comprises medium to long-term government and government guaranteed borrowings plus short-term borrowings of the banking sector. Total public and publicly guaranteed external debt stock (disbursed and outstanding) remained at around 40 percent of GDP in both 2003 and 2004. In absolute levels this amounted to 289.5 million US$ in 2003 and had increased by 7 % to 310.1 million US$ at the end of 2004. Of this total, around 94 % was on medium and long-term debt. Borrowings from multilateral and bilateral sources constituted two third of the medium to long-term external debt portfolio and grew by 4 % on annual terms. The remaining 33 % comprised suppliers' credits and commercial loans, which increased by 11 % during 2004. Meanwhile, short-term debt, which reflects the foreign liabilities of commercial banks, comprised over 7 % of the external debt stock and registered an increase of 22 % at the end of 2004. Disbursements of medium and long-term loans during 2004 stood at 47.6million US$, while amortization was recorded at 20.4 million US$, and interest payments amounted to 5.7 million US$. Total debt service therefore totaled 26.1 million US$ in 2004, equivalent to around 4 % of Maldives' exports of goods and non-factor services[17].

(2) Government Debt Practice and Monitoring Mechanism

Having stated above, the government practices borrowing money for the development projects from the multilateral development banks such as ADB and the World Bank, and the short-term loan from commercial banks, and the remaining gap is filled with the cash supply from MMA or Maldives Monetary Authority[18].

The debt balance is considerable as stated above, however, the repayment to the loan is well managed with no record of the arrears so far. In addition, the Ministry of Finance and Treasury (MFT) pronounce to the donor community that they are very cautious to the further increase in loan portfolio. And ADB assisted in 2005 the capacity building of the debt management unit of MFT to monitor by themselves the inflows of debt and the outflow of debt repayment for the future.

The MFT has now the unit, which was trained by ADB-funded consultants to manage the debt balance with the software of CS-DRMS[19], or the Common Wealth Secretariat-debt record and management system. In short, donors may put high credibility to the debt management of Maldives.

(3) Debt service ratio (DSR)

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[17] This is a summary of *Overview of Economic Developments During 2004*, based on the information as of 20th April 2005 by Maldives Monetary Authority (http://www.mma.gov.mv/red.php)

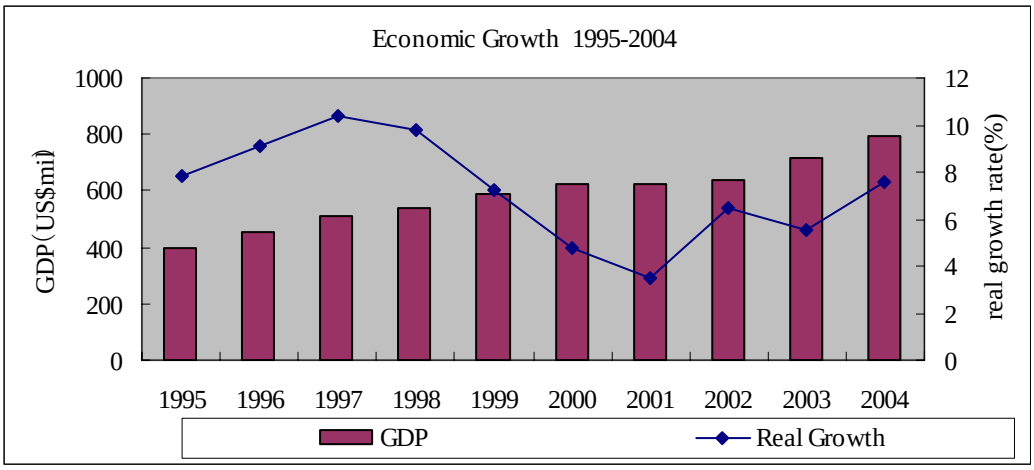
[18] MMA is the central bank with the authority of issuing the currency.

[19] Common Wealth Debt Record and Management System, which is a software widely used to monitor the debt balance.

Usually, when looking at risk of lending loan to the other country, the typical indicator of assessing risk of arrear or default is debt service ratio (DSR), that is defined as the amount of annual repayment as numerator over the amount of foreign currency earnings of the year as denominator. In case of Maldives, the denominator is the exports of tuna-products and others, plus the revenues from tourism. In case of Maldives the denominator is very large compared to the numerator. This implies that the country can easily repay the annual repayment to the creditors Even if the country further borrows from the donors such as JBIC, the World Bank, ADB, and the IDB, the DSR will not rise significantly.

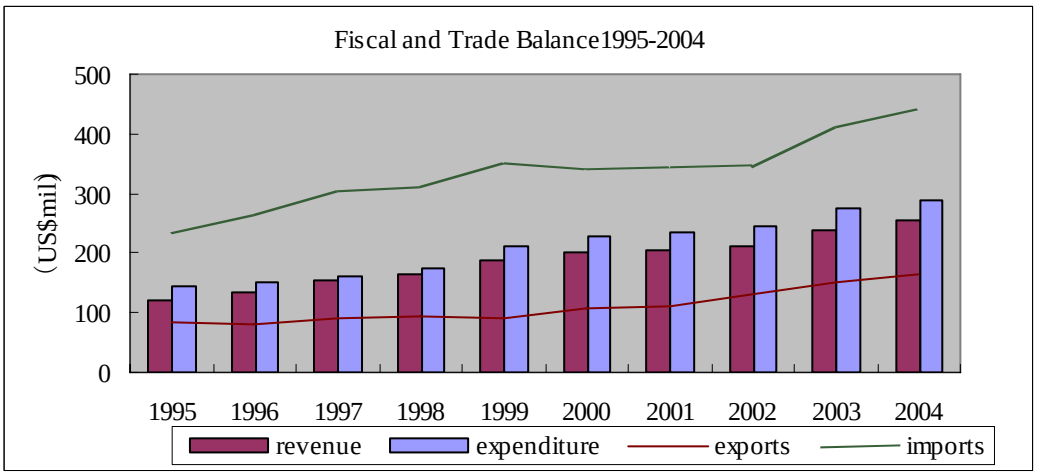
(4) Risks

The repayment may encounter difficulty if a sudden negative change in macro economy, that is, in revenues from exports and tourism occurs. And it is often said that a small country with open economy is very susceptible to the sudden down turn in the world economy. However, the recoverability of the small country is also high since the damage and population to be taken care of is small. This seemed to be very much proved by the tsunami-incidence of this time.



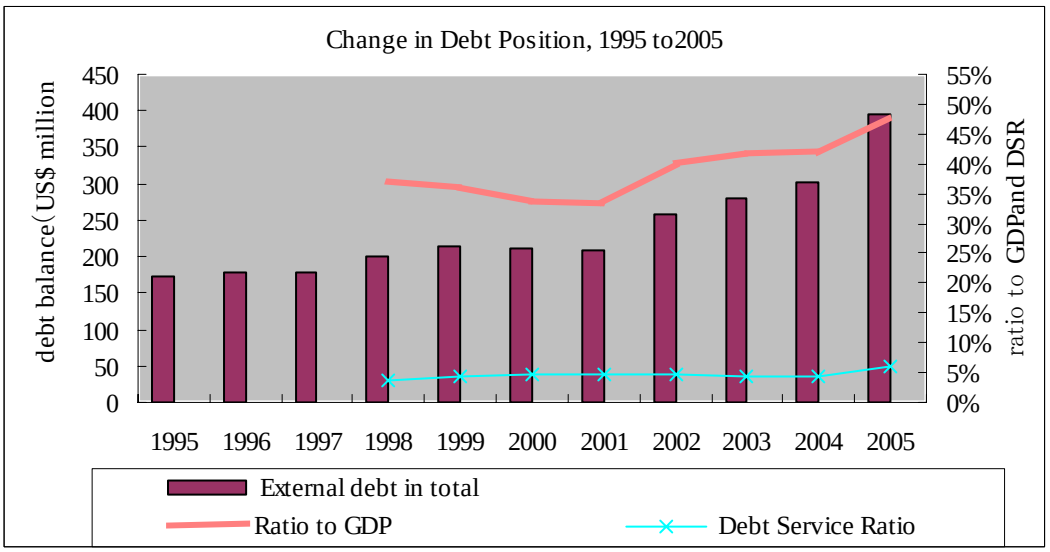
Source: MOFT, etc.

Figure 11.1 Economic Growth



Source: MOFT, etc.

Figure 11.2 Fiscal and Trade Balance



Source: MOFT, etc.

Figure 11.3 Debt Position

11.3.6 Financial and Economic Analysis

(1) Isdhoo Project

The sewerage project of the Isdhoo Island, Laam Atoll will be soon implemented on a Japanese grant basis[20]. SAPROF team has compiled several candidates aside from Isdhoo. However, it is uncertain at this moment of JBIC's commitment on a particular project. Thus, in this section, we attempt to conduct a sample study of a sewerage project in Maldives by utilizing the incoming Isdhoo Island project. The project has the following economic and financial characteristics:

1. The capital cost is fully born by the donor, so the users have to bear only cost for anticipated operation and maintenance costs.
2. According to the plan, the Island Development Committee (IDC) will manage the system, and assign five persons to engage in daily maintenance.
3. Each household equally shares the running cost. The monthly sewerage fee to each household is Rf. 64. Suppose the average expenditure of the low-income household is Rf. 3,500 per month, the fee amounts to 1.8% of the expenditure. This amount is not considered to be very low, but affordable[21].
4. Apparently, if the capital cost is counted, the project will have to charge Rf.245, or 19 US$ or 7% [22] of the average expenditure of the lowest income group to obtain around zero percent of FIRR. The high fee rate is not realistic, thus the sustainability of the system will not be guaranteed. This result reflects the difficulty of sewerage development in the rural area, thus has low priority from the national economic point of view. Hence, the government or the donor must bear the initial cost as is planned.

(2) General Discussion on Possible JBIC Projects

1) Sewerage projects

The list of sewerage projects and estimated costs are as follows (Table 11.5).

[20] See the relevant chapter.

[21] According to the social economic survey, which was conducted by the ADB technical assistance, 45% of the population is willing to pay 2% of their income for improved sanitation.

[22] Based on the same assumptions as those for SAPROF, EIRR is also calculated. To get a break-even, 6% of the expenditure is required.

Table 11.5 Project Cost of the Candidate Sewerage Projects by SAPROF Team (in US million)

	Island	Construction cost	Physical contingency	Engineering service	Administration costs	Subtotal
1	Ha.Dhidhdhoo	1.908	0.191	0.286	0.057	2.442
2	Ha.Filladhoo	0.507	0.051	0.076	0.015	0.649
3	Ha.Baarah	0.992	0.099	0.149	0.030	1.270
4	Hdh.Nolhivaranfaru	0.472	0.047	0.071	0.014	0.604
5	Sh.Funadhoo	1.104	0.110	0.166	0.033	1.413
6	N.Manadhoo	1.351	0.135	0.203	0.041	1.729
7	B.Eydhafushi	1.399	0.140	0.210	0.042	1.791
8	Adh.Maamigili	1.960	0.196	0.294	0.059	2.509
9	M.Muli	0.596	0.060	0.089	0.018	0.763
Total		10.289	1.029	1.543	0.309	13.170

Project objectives

The objective of the above project is to improve living conditions and human well being in the atolls of the Maldives. The project will improve sanitation practices in the future. The main beneficiaries of the project will be the inhabitants of the islands.

General principles for financial and economic analysis

In general, the financial analysis of the project estimates the profit accruing to the operation entity or the project participants. On the other hand, economic analysis will measure the effect of the project on the national economy. The proposed project may be the case that it is focused on an investment with unclear or longer-term benefits that are not easily identified. For example, the monitoring of ground water quality over time and the impact to human health will not be easily measured with no clear economic outcomes, but essential in the longer term for human health and natural environment. The economic analysis will attempt to assess the overall impact of the project on the economic welfare of all the member of the targeted society, and will measure the positive and negative impacts of the project.

Economic and financial assumptions[23]

For this study, the following general assumptions are adapted.

- All revenues, benefits and costs are expressed in mid 2005 prices.
- The implementation period for the project is less than one year in 2005.
- Inflation is not taken into account.
- The project is analyzed for a period of 35 years or assumed project life.
- The average 2005 official exchange rate of 12.75 Rf. per US$ 1.00 is employed in converting foreign exchange costs to their local currency equivalent.

[23] Asian Development Bank, *Economic and Financial Analysis, Appendix14*, *RRP:MLB 33218, Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the Republic of the Maldives for the Regional Development Project, Phase 2, Environmental, Infrastructure and Management*, pp.55-71, April 2005.
This report is a major reference for this section, unless otherwise noted.

- Analysis is conducted in domestic price, expressed in Maldives Rufiyaa. Tradable goods and services were converted into domestic prices by using the standard conversion factor or SCF, which is estimated to be 0.9[24].
- To simplify the calculation, all inputs for the initial construction and O&M are regarded as imports, hence, the conversion factor is applied.
- SAPROF team estimates the population covered by each in 2005.
- Average household size in each is given by the 2000 Census.
- The number of household is derived from dividing the population by the average household size.
- We take 35 Rf. as the monthly fee unit, which approximately represents 1% of the monthly average expenditure of the lowest 20 % income of households. And we assume the collection rate is 100% since the community members themselves operate the system.
- Annual O&M cost is set at one percent, based on the Isdhoo case.
- There is a wide range of economic and social benefit including aspects of environment, water resources, health, institutional development, employment, direct and indirect, and gender. However these aspects are not quantifiable or take too much time to collect, even not impossible. The benefit is only measured by the amount of fees[25]. This is the limitation of this analysis.

Results of financial and economic analysis

Since the project is on sewerage sector in the rural area, the financial analysis shows unfavorable results. In order to obtain a break-even at FIRR, that is, avoid negative value of the project, the project will have to charge at least a fee of 4% to 8% of the average expenditure of the lowest-income household. This is very unrealistic. Moreover, for FIRR to get a level of opportunity cost of capital in this country[26], which is usually the decision making point of the project, the project will have to charge double or triple of the above rate.

As for the economic analysis, although the cost of initial and O&M is lower with the conversion factor, the figures derived do not change much with those of FIRR, perhaps due to the fact that economic benefit, to be generated from the project, cannot be quantified (refer to Table 11.6).

Affordability and Sustainability

The social objective for tariff formulation is to ensure that all members of the community are able to afford access to clean water supply and to waste water disposal services without excessive burden on their expenditure. Thus, the tariff structure needs to be designed so that full cooperation from the less-income household can be obtained.

In principle, to implement waste water services it is necessary to consider this in the context of

[24] The simple estimate formula is as follows. SCF=(Import+Export)/((Import+Import Duty)+(Export- Export Duty)). We have computed it using 2004 data.
[25] We do not compute so-called consumers' surplus, either.
[26] ADB estimates 12%, and the on going lending rate at private sector is 8-13% as of June 2005.

affordable tariffs not exceeding 5% of the household income for water supply, waste water disposal, etc.

To measure the affordability or ability to pay, we focus on the bottom 20 % income group. Based on *the Year 2000 Census*, we assume the monthly average expenditure/income of the lowest income group as 3,500 Rf.[27]. Thus, 1% is 35 Rf., and 2% is 70 Rf.. Apparently, to make it sustainable, the project will charge only annual O&M cost to the community. If so the community may afford to pay for the cost[28]. With the simple calculation the fee ranges from 1.1% to 3.2% of the average income of the lowest-income household. The community may be able to pay in case of 1%, but not easy in case of 3%.

Table 11.6 Summary of Proposed Fees

	Island	Fee level to get zero FIRR	Fee level to get zero EIRR	Fee level to cover O&M
1	Ha.Dhidhdhoo	5.0%	5.0%	1.3%
2	Ha.Filladhoo	4.0%	4.0%	1.1%
3	Ha.Baarah	6.0%	5.0%	1.4%
4	Hdh.Nolhivaranfaru	7.0%	6.0%	1.7%
5	Sh.Funadhoo	7.0%	7.0%	1.9%
6	N.Manadhoo	8.0%	8.0%	2.1%
7	B.Eydhafushi	6.0%	5.0%	1.4%
8	Adh.Maamigili	8.0%	7.0%	3.2%
9	M.Muli	7.0%	7.0%	2.1%
Reference	L.Isdhoo	7.0%	6.0%	1.8%

Note: 0ne percent of the average income of the lowest-income household is assumed at Rf.35. This table indicates the level of the burden to the household.

2) Economic Consideration for the Port Projects

Maritime transport sector[29]

The country has about 90 man-made harbors with quays, basins and breakwaters. And there are natural harbors, jetties, and approach channels to access inner atolls to service the 200 inhabited islands as well. However, most of the islands lack proper facilities. More than half of the inhabited islands indicate inconveniences in access. The reasons are improper harbor facilities, lack of jetties, difficulties with lagoons or entrance channels, and adverse weather conditions.

[27] MPND, *Household Income and Expenditure Survey 2002-2003*, The median income per person per day at the survey year is 23 Rf. and average expenditure of the lowest 20 % group is at 17 Rf. per person per day in the atoll. At the site island of the Isdhoo, the average household size is estimated at 6.8. Combining the above two, we will get the average household income of 4,692 Rf., and the average household expenditure of the lowest 20% quintile of 3,468 Rf. For simplify, we assume Rf.3, 500 as the benchmark level for this analysis.

[28] ADB and World Bank requires for a portion of the construction cost borne by the community, which ranges up to 20%. It is usually paid through labour participation in the work.

[29] ADB, World Bank, UN, *the Joint Tsunami Assessment*, February, 2005

Damage to the sector

According to the initial quick assessment, 36 jetties are reported to have some damage, a total of 19,200 meter length of quay walls and sea walls/breakwater lengths need repair and a total volume of 520,000 m^3 of harbor basin and approach channel dredging is considered necessary due to sedimentation. The total cost of the damages is estimated at 24.45 million US$. Out of this, the cost of immediate needs program for the transport sector would be around 2 million US$. The medium and longer-term needs are estimated to be at 22 million US$[30].

Number of vessels

The number of vessels registered in 2003 is 10,578, in which the number of dhonis are 7,154 and others vessels 3,434. The 14 proposed harbour projects cover 9 atolls, which in total register 6,511 vessels (3,961 dhonis and 2,550 others). This covers 62% of the total vessels in Maldives (55% of the dhonis, and 74% of the non-dhonis).

The dhonis or small vessels are popular and extensively used in the country. They carry 20-30 passengers from one port to another with a low fare, or carry daily necessities, or carry passengers and cargos together. Hence, the safe or safer port is indispensable for the passengers and cargos.

Justification to the projects

The local port project does not necessarily fit to the economic and financial analysis due to the simple fact that benefit, although exists, cannot be quantified. The investment to the listed projects is a large amount, however, to rehabilitate and upgrade the island harbour is critical in social and economic development in the medium to long term. Hence, It is worth implementing those, one by one. But projects with apparent high benefit relative to the cost shall have high priority.

Economic Efficiency

The other consideration on the port reconstruction or development is efficiency of the investment. When calculating given figures of the investment and the population of each island, that, the potential users of the port, on an average of 11 projects we will invest 304 US$ per person. The most efficient one is, no doubt, on the capital island of Male' (17 US$ investment per person), while the worst one is on the Th. Dhiyamigili (5,556 US$ per person). From the public investment point of view, the projects with high efficiency shall have priority on the listed projects, in the meantime projects with less efficiency may find an alternative way of implementation.

[30] Assuming that insurance cover 50% of the damages to the Male Commercial Harbor and the International Airport.

Table 11.7 Project Costs, Population and Economic Efficiency

	Island	Estimated cost in million US$	Population	Investment per person in US$
1	Hdh.Makunudhoo	3.7	1,308	2,829
2	Sh.Funadhoo	5.55	1,334	4,160
3	N.Lhohi	1.9	714	2,661
4	Male	1.26	76,350	17
5	K.Maafusi	3.41	1,169	2,917
6	Th.Hirilandhoo	0.44	932	472
7	Th.Dhiyamigili	4.2	756	5,556
8	L.Isdhoo	0.32	1,103	290
9	L.Kalhaidhoo	0.44	1,103	399
10	L.Fonadhoo	3.75	1,708	2,196
11	Ga.Dhaandhoo	1.83	1,675	1,093
	Total	26.8	88,152	304

Note: costs and population are estimated by SAPROF as of June 9, 2005. The SAPROF team proposed 14 harbors, and estimated the costs of the above 11 harbors.

11.4 Recommendations

11.4.1 Macro Economic Perspective

The country enjoys long-lasting political stability and economic growth. Although small countries like Maldives have many external factors to impact the economy, the country has a capability of quick recovery, thanks to the smallness itself, which was just proved during the course of recovery from this tsunami disaster.

In addition, the government shows good governance and strong grips on fiscal management. That is, to contain the government deficit below the manageable level. And the annual trade deficit, not small, is well offset by an inflow of tourism revenues.

As for the debt management, the MFT has a capable unit to monitor the repayment schedule so that the risks of arrears are almost nil from the creditors' point of view.

The public sector, like any other developing countries, may need further enhancement in terms of quality and quantity of public servants. This is well recognized among donor communities. Thus, technical assistance will be continuously received from major donors such as ADB, the World Bank, and UN agencies. This effort of capacity development for the public sector can be another guarantee to donors if they, either by loan or grant, would like to implement a particular project.

We will not disregard the risks. When looking at internal issues, the country may face two development issues: one is a large disparity between the urban and the rural, or the capital and the atolls; the other is a little hope for new industries to earn foreign currency and to absorb the young work force. Thus, the government policies for development must be in line with these two objectives. Hence, the donor assistance must be coordinated with this government direction of pro-equality and pro-industry/pro-employment.

The key is a speed, however. When the progress is slow, or is regarded so by the public in general, a social uneasiness may occur, as is often the case in developing countries.

11.4.2 On Projects

The two areas, that is, the Laamu and Thaa Atolls will be among the top priority to rehabilitate the social and economic infrastructure such as public buildings, harbors, jetties, and causeways, etc. The damage to these two atolls is significantly large, and hinders the daily social and economic activities of the atoll residents. Thus, it is worth to do the rehabilitation.

By rehabilitating the port facilities at these atolls, the sea transport among the islands will become safer, and more relied-on, and the fishing activities will become more active. And in the long run, function of disaster prevention will be strengthened with the ports rehabilitated.

The preliminary economic and financial assessment for a planned sewerage at the Isdhoo Island, the Laam Atoll, clearly concludes that the project is sustainable at an affordable user fee since the construction cost is on a grant basis.

There is a list of SAPROF-proposed projects in both sewerage and harbor sector. For the sewerage, we tried to calculate the FIRR and EIRR, based upon the assumption for the Isdhoo project. The derived figures with assumptions are very pessimistic due to the obvious reasons that these are social, not economic, projects in the population-sparse area. This suggests that the burden on the community be only limited to the operation and maintenance cost during the course of the project life.

Although the amount of investment in total to these projects will not be very small (13.17 million US$ at an estimate by SAPROF team), it is worth implementing them after the initial recovery stage. These projects will be financed by an extremely concessional loan, and will be in line with the National Development Plan.

As for the harbour projects, we are unable to derive any calculated figures, since a difficulty in quantify meaningful economic benefit exists. This is inevitably associated with the local islands harbours. Although the total cost is not small (26.8 million dollars at an estimate by SAPROF team), it is worth implementing one by one after the initial recovery stage. The finance shall be made at an extremely concessional terms. And the construction of maritime transport network is a priority on the on-gong National Development Plan and the incoming new plan, and the Transportation Master Plan of 2004 (not finalised yet), most likely.

11.4.3 Recommendations

Since both side, more or less, agreed to the candidate sewerage and houbour projects for JBIC concessional loan, at the implementation stage, both side shall further study the implementation scheme with sustainability for each subproject.

Besides, in the medium to long run, donors may assist the counter part agencies of the relevant sector, if requested, to fine-tune the existing development strategies, the guidelines, the relevant laws, and the regulations, or to draft these if not available, not to mention that donors shall upgrade capacity of the relevant organizations

Although JBIC is concerned about two sectors only this time, the other sectors such as emergency telecommunication are as crucial as well. Apparently, the government runs public finance very well so that the fund for hardware may be from the government, in the meantime so-called “software of the system” including the organizational structure and relevant laws, may be assisted by experienced donors, if requested.

Aside from this, in the long run, atoll or/and island development plan, although seems to exist, shall be revisited to make it more realistic in order to ease the two gaps hanging over the Maldivian society: the gap between the capital and the islands, and that between the job requirements and the young job-seekers.

Chapter 12 COMMUNITY BASED RECOVERY PROJECT (Demonstration Project in Laamu Fonadhoo)

12.1 Outline of the Project

A community based recovery project was proposed and designed by the series of discussions, coordination and site surveys held on the preparation stage of the study. At the same time, Fonadhoo Island, one of the most affected islands by the tsunami (fully destroyed; 49 houses, partly destroyed; 197 houses) was selected as a target community.

There are two aspect of recovery planning, one is a mutual cooperation among governmental relief, self-reliant and community empowerment, and the other one is combination cooperation between rehabilitation of infrastructure and living environment. In deed it is highly effective to have both aspects simultaneously regarding Japan's disaster reconstruction experiences. Thus this project focuses on enhancement of the community empowerment in the mutual cooperation and takes responsibility of recovering living environment in the combined cooperation.

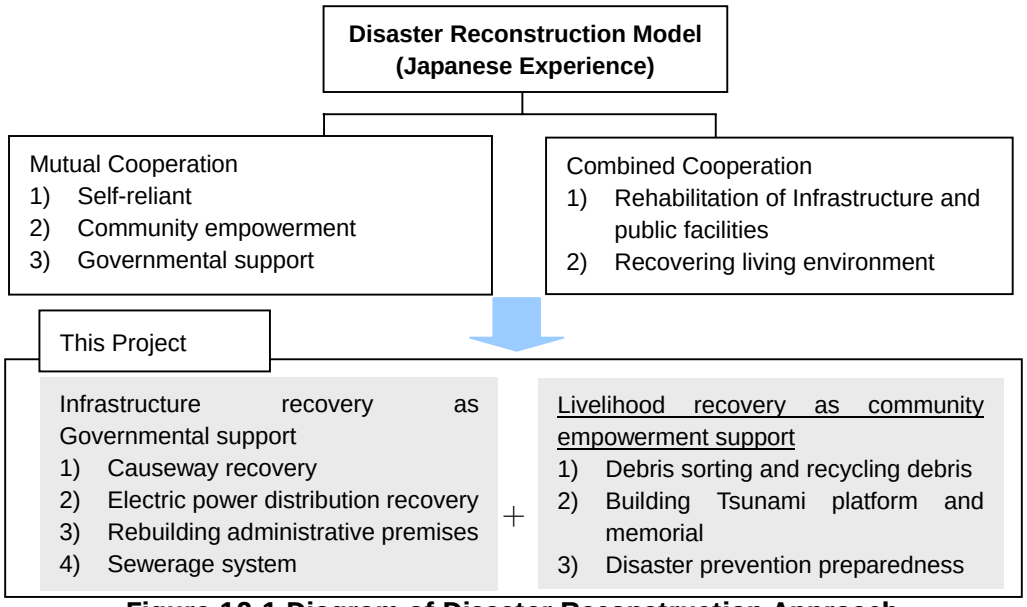


Figure 12.1 Diagram of Disaster Reconstruction Approach

Assistance in a community's post-disaster efforts for recovery, rehabilitation and development is most effective when administrative support from the government, self-reliant efforts by the residents and mutual cooperation among local societies are adequately tied and coordinated. For this purpose, the Study Team implemented a community based project which involves the residents' participation in recovery activities as a community-based initiative, in addition to short-term recovery projects that covers rehabilitation of infrastructure and public buildings implemented by the government, in order to enhance the country's recovery and reconstruction efforts.

Based on site surveys and discussions with the community in Fonadhoo Island, the project

component was planned, which covers three sub-projects namely 1) Clearance of disaster waste and debris recycling, 2) Building evacuation platform and tsunami disaster memorial monument 3) Education of disaster prevention preparedness.
The component was planned based on these backgrounds;
1) Disaster waste, debris of destroyed houses and walls by tsunami, were spread in the community and some clearance was done assisted by the government and NGOs right after the tsunami, however, many of debris gatherings are still observed in the community even it has been several months. An element of the debris is mainly mortar and coral rock.

Concerning geographical conditions of Maldives, it is quite limited resource for construction materials and banning of coral mining so that most of the construction materials are imported from neighbouring countries. Regarding destroyed houses and walls, most of them were built by masonry structure with coral stone. Under these situations, recycling of debris is an effective use of resources by the community participation and it can be capable work to be done by the community.

2) In addition, the community has strongly requested to have evacuation platform due to that the people could not find proper refuge when the second earthquake occurred on 28th March, 2005. It is essential that building evacuation platform with the tsunami memorial in the community using recycled blocks is indispensable. The platform with the memorial has a role of bequeathing the disaster to next generation.

3) Moreover, it is not only facilitating physical aspects but also an enhancement of community empowerment is highly concerned aspect, which is to enlighten the community in regard to the disaster prevention and the preparedness for further natural disaster. Thus disaster prevention education is vital for the community.

Consequently the project was planned with community participation and cash-for-work as an ad hoc measures in order to precede groundwork for the community's further reconstruction efforts

12.2 Framework of the Project

(1) Project Title
The project was named as "Community Based Living Environment Recovery and Disaster Risk Management Project" or "Community Based Recovery Project" in short, after dialogue among the stakeholders in the central and local governments.

(2) Objectives
The objectives are as follows and the logical framework is illustrated in Figure 12.2.

Overall Goal:

To improve community empowerment towards natural disaster

Project Objectives:

i) To recover the living environment deteriorated by the tsunami disaster by the community itself (clearance and recycling of debris resulting from the tsunami disaster)

ii) To provide groundwork for the community's further reconstruction efforts (construction of a platform to serve as an evacuation shelter as well as a memorial of the disaster)

iii) To enlighten the community in regard to the disaster prevention and the preparedness for natural calamity (education of disaster prevention)

(3) Project Description

1) Project Component

i) Clearance of disaster waste and debris recycling

ii) Building evacuation platform and tsunami disaster memorial monument

iii) Education of disaster prevention preparedness

To achieve the project objectives, the following activities are proposed.

Table 12.1 Main Activities on Demonstration Project

No.	Main Activities	
(1)	Project awareness and setting up block production yard	• Awareness of the Project • Setting up the Recovery and Disaster Risk Management Unit under Island Office and CBOs in Fonadhoo • Setting up the concrete block production yard by the Team and Community
(2)	Collection and sorting out of debris and wastes	• Preparation of the list of sorting items and list of disposal place by joint inspection with the community and the Team • Clearing and sorting out of debris and wastes by Community
(3)	Production of recycled block	• Preparation of the production manual of recycle concrete block based on trial and errors by the Team • Procurement of necessary equipment and materials for construction of concrete block by the Team • Training for production of the concrete block by the Team • Crushing coral rock by hand or machine by the Community • Mixing material based on the manual by the Community • Curing of concrete block by the Community
(4)	Planning, design and construction of Tsunami monument and evacuation platform	• Confirmation of needs on Tsunami monument / evacuation platform by having dialog of the Team and Community • Collection of the ideas and designs of the Tsunami monument from the pupils (Give the testimonials to the collected good ideas) • Team and the Community and finalize the design of the monument • Draft design of Tsunami evacuation platform by the Team and Unit • Ratification workshop with the Team and Community to finalize the plan and design of Tsunami monument / evacuation platform • Construction of Tsunami evacuation platform by the Community • Construction supervision by the Unit and Team
(5)	Project monitoring	• Monitoring and evaluation of efficiency, achievement, impact, rational, sustainability. • Making opinion poll of the participants • Providing leaflet of the Project • Making documentary film

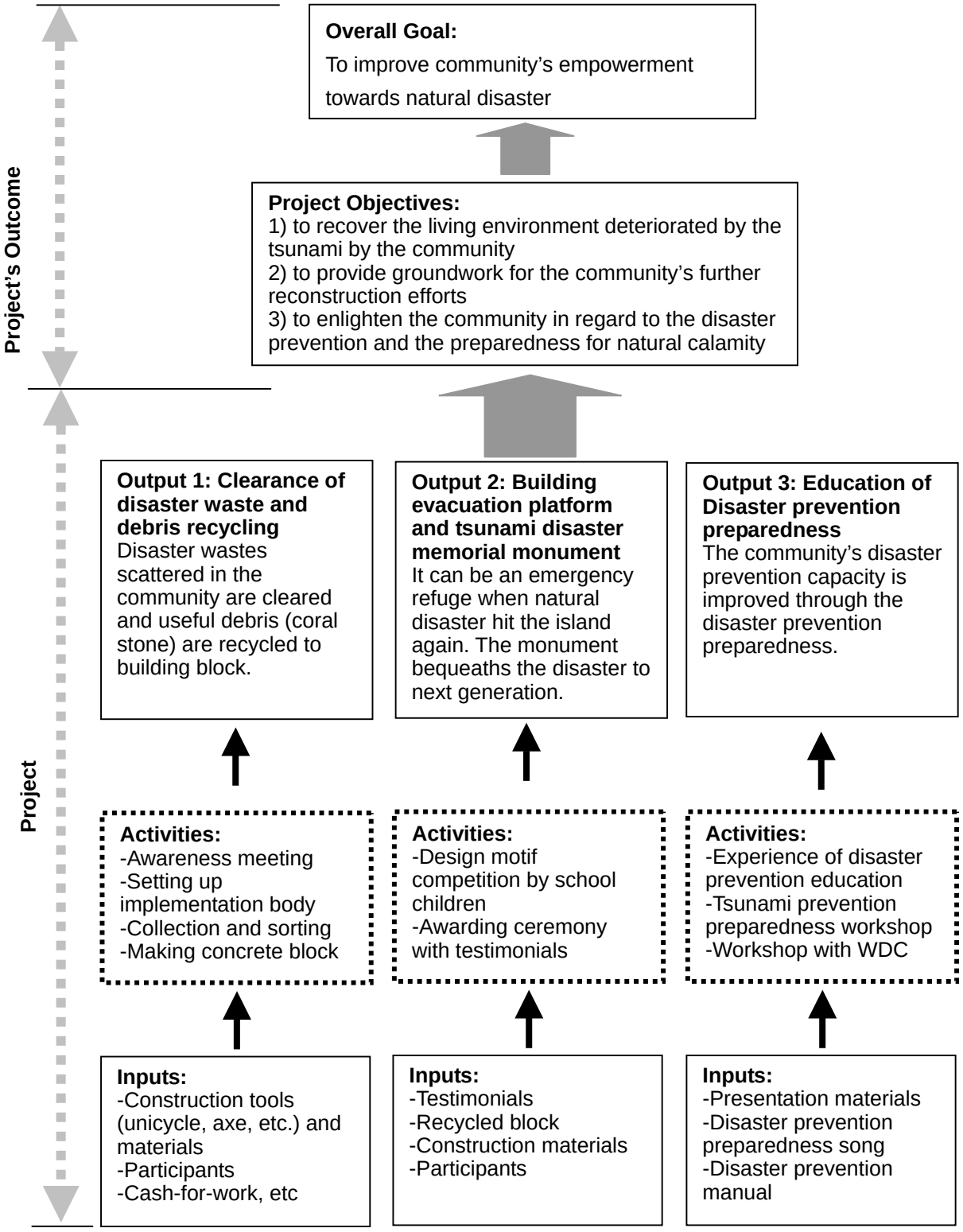


Figure 12.2 Logical Framework of the Community Based Recovery Project

2) Organization of the Implementation

The project implementing organization is shown in Figure 12.2.

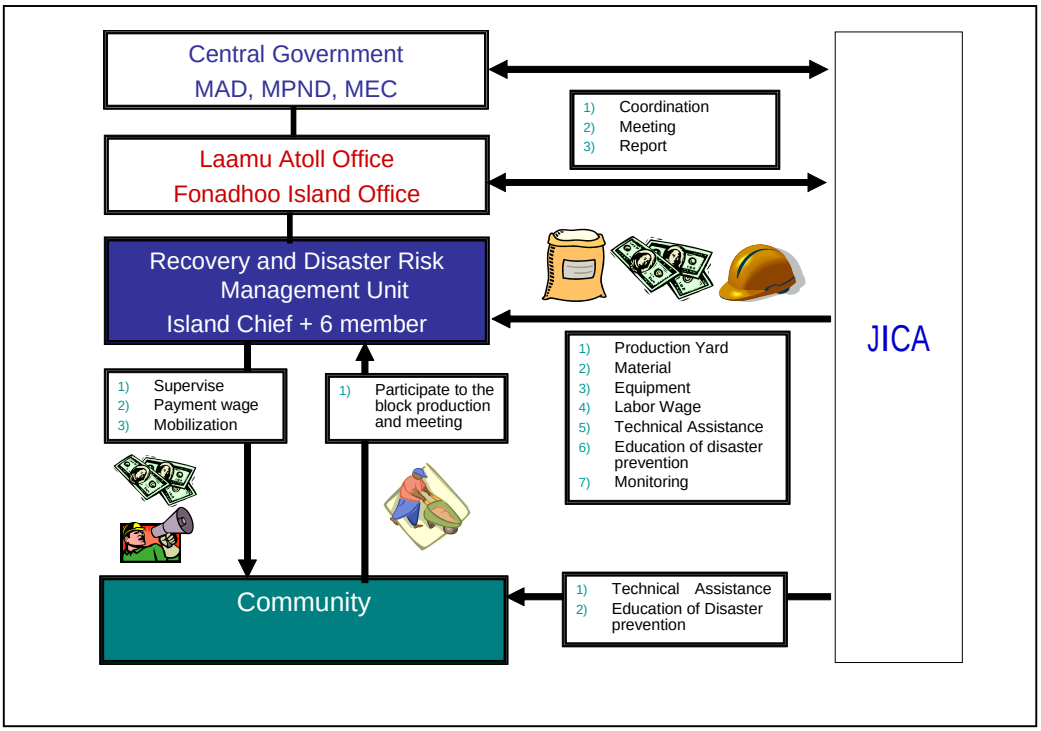


Figure 12.3 Implementing Organization of the Project

3) Project Site

The project is implemented in Laamu Fonadhoo, which is the capital of Laamu Atoll, located at 1 ° 50' North and 73 ° 30' East, 260 km south of Male' with an area of 159.2 ha.

4) Project Duration

The project duration is six months from beginning of June until beginning of December 2005.

5) Project Beneficiaries

The project beneficiaries are the registered population in Fonadhoo of 1,740 with 262 households[1]. There are three wards in the island, namely Barrasil, Medhuavah and Kurigamu. There is one island office in Fonadhoo and two island chiefs with three assistant island chiefs are handling the administrative matters. Functioning committees are the Island Development Committee (IDC) and Women's Development Committee (WDC) with 16 and 22 members nominated respectively.

[1] Statistical Yearbook of Maldives 2004

12.3 Activities in the Project

12.3.1 Preparation of the Project

(1) Awareness to the Project

Meetings to make the project concept and objectives known as well as understood by the people in Fonadhoo were held on 26th and 27th May, 2005 in the social centre in Medhuavah and the community hall in Baraasil with cooperation of the Island Office and the Atoll Office. The participants were 114 in the first meeting and 70 in the second meeting. It covered two thirds of the households on the island. The participants in each meeting accepted the project concept, objectives, implementing schedule and implementing organization.

(2) Establishment of the Implementing Organization

The project implementing organization called “Recovery and Disaster Risk Management Unit (the Unit)” was organized under the Fonadhoo Island Office, IDC and WDC. The seven personnel were nominated as members of the Unit, including two from the Island Office, three from the WDC, one designated by the IDC and one from the private sector. In addition to the seven members, the assistant principal of Laamu Atoll Education Centre joined the Unit as an advisor. The Unit made administration, finance and technical sub-unit and defined the role of each member. The article of the association for regulating operation of the Unit was prepared by the Unit and the Study Team.

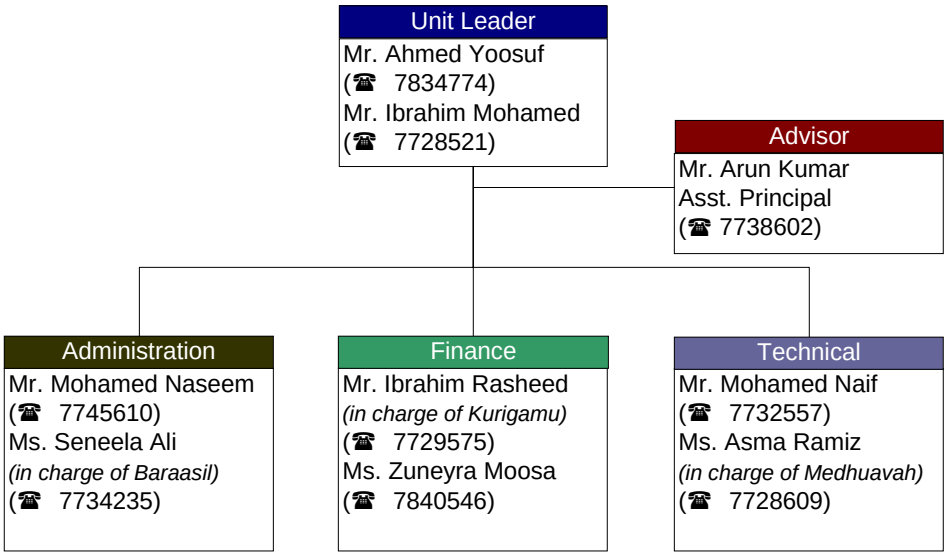


Figure 12.4 Recovery and Disaster Management Unit

The view of clearing of debris

12.3.2 Clearance of Disaster Waste and Debris Recycling

(1) Clearance of Disaster Wastes

41 debris clearing spots were identified in Fonadhoo after inspection of the Unit and the Study Team and dialogues with the Unit and the islanders. The 41 spots are composed of 4 in the Kurigamu ward, 8 in Baraasil and 29 in Medhuavah. After the on-site training, the clearing of debris actually started on 5th June, 2005. The debris was cleared by wheel borrowers or pickups and carried to the recycle block production yard. The clearing continued until 12th July, 2005. During the six weeks following 5th June, debris were cleared in 33 points out of 41 and carried to the recycle production yard 151 times by a two-ton pickup. The cleared debris was about 150 m^3 equivalent to 250 tonnes.

(2) Sorting and Processing of Debris

After carried debris to the block production yard, debris was sorted and processed for recycling. The sorting and processing activities started on 13th June, 2005 after on-site training by the Unit and the Team. The sorting and processing of debris were carried out by axe based on the “Debris Processing Manual” prepared by the Unit and the Team. The debris was mainly sorted to coral, mortar and others.

(3) Production of Recycled Blocks

The recycle production yard was scheduled to locate in the southern part of Medhuavah ward. Prior to commencement of the construction of the recycled block production yard, the site was voluntarily cleared by the community. More than 20 persons in the community, mainly female, spent two days for the clearing work. After clearing the site, construction of recycle block production yard was started on 24th June, 2005 and completed in end of July 2005. During construction of the recycle block production yard, the Unit and the Study Team conducted trial mixing to determine a suitable ratio of the mixture.

The site of block production yard (30mx30m) was cleared by the community under supervision of the island chief.

Overall profile of completed block production yard

After trial mixing of the block, the ratio by weight per batch (one mix) was fixed as follows:

- Cement: 50kg (1 bag)
- Fine Sand: 200kg (4 bags)
- Water: 25kg
- Recycled mortar including coral stone: 64kg
- Add 1kg coral stone for surfacing per block

The production was started on 14th August 2005 by participants from the community. The works were carried out according to the production manual prepared by the Unit and the Study Team. Twenty five (25) blocks per mix were produced in average. Production of three thousand (3,000) blocks for using in the evacuation platform as the minimum target was accomplished in beginning of September 2005. The production was continued until 8th December 2005 for using in other purposes to be decided by the community. The total production was 18,575 blocks.

Taking mixed mortar and proceed to pouring the mixture to mold。

Compacting the poured mixture by stick

Competed blocks after removing the mold

The community people are taking pleasure in increasing the completed blocks as their accomplishment at the temporary stock yard.

12.3.3 Building Evacuation Platform and the Tsunami Memorial Monument

(1) Planning and Preparation

The draft plan and design of the tsunami monument and platform were discussed among resource persons in Fonadhoo. The Atoll Office, Island Office, IDC, WDC, representative of each ward, NGOs, businessmen, the Unit members and the Study Team members participated in the meetings held on 13th June and 5th July, 2005, where the location, shape, size and height of the monument/platform was drafted to show to the community for their approval.

The view of Tsunami Drawings

(2) Design

At the same time, drawings with a motif of the tsunami were gathered from the students in the Laamu Atoll Education Centre. 230 students in grades 1 to 9 drew pictures of tsunami. The same resource persons selected eight pictures from the 230 as the pictures to covey the tsunami experience to the next generation. Selected pictures are printed on the tile and put on the wall as a monument.

The ratification meetings for the tsunami monument and platform were held on 18th, 20th and 21st July, 2005. The participants (totalling up to 270) generally accepted the proposed plan but raised some comments on the location and stairs. Based on the comments, the Study Team requested the community to have the Island Development Committee Meeting assess the comments on the location of the tsunami monument and platform. After the assessment by the Committee, the location was decided as the park in front of the harbour as proposed. The decision was made considering the demonstration effect, distance from the jetty and each village and handiness in case of emergency. In the meeting two persons pointed out that it would require two staircases to evacuate the people smoothly. The Team agreed to estimate the cost and to make final decision. The following is proposed as a final plan for the tsunami monument and platform.

Table 12.2 Proposed Design of Tsunami Monument and Evacuation Platform

Location	Park in front of the harbour, next to the new island office
Size	42 m^2
Shape	Hexagon with steps, slider and storage on the ground floor
Height	2.6 m plus 1.4 m parapet wall
Monumental Facilities	8 tsunami tile pictures and 2 photos plus memorial plate in Devihi and English. The important message from both Maldives side and Japan side are also indicated in the memorial plate.
Others	Covered with the recycle blocks

(3) Construction

Construction of the platform and monument was started on 14th November 2005. The construction is scheduled to complete in middle of January 2006.

12.3.4 Education of Disaster Prevention

(1) Outline

This activity was done by JICA as a part of the community based recovery programme of JICA Study, thus it is briefly explained in this report. This activity was proposed and discussed on the Scope of Work meeting held in April 2005. Disaster Prevention Policy through community was highly concerned by DER/MFA, MOAD and MPND, and the Minutes of Meeting, Part II Reconstruction, described it and both side agreed on.

JICA sent two experts, one was for community self-sufficient support and the other one was for disaster prevention education. These experts stayed in Maldives from 22 to 27 of July 2005. A series of activities such as a presentation of experience of disaster prevention at Futto primary school in Aichi, Japan, a workshop of disaster prevention based on disaster prevention manual prepared by Kochi Prefecture, Japan, discussions among school students and teachers, Fonadhoo Women's Development Committee, etc., were held.

(2) The Schedule

Table 12.3 Schedule and Activities of JICA Expert for Disaster Prevention Education

Date	Venue	Activities
22 July 2005 (Fri)	Male (Arrival)	Atoll Chief, Island Chief, Women's Committee
23 July 2005 (Sat)	Male-Fonadhoo	Kick off and awarding ceremony at Education Centre
24 July 2005 (Sun)	Fonadhoo	Presentation of Japan's experience regarding disaster prevention education
25 July 2005 (Mon)	Fonadhoo	Workshop of Disaster prevention in Fonadhoo Island, Feedback meeting
26 July 2005 (Tue)	Fonadhoo-Male	Internal meeting
27 July 2005 (Wed)	Male-Colombo	Meeting with UNDP Maldives, the Study Team
28 July 2005 (Thu)	Colombo	Reporting to Embassy of Japan, JICA Sri Lanka
29 July 2005 (Fri)	Colombo-Japan	

(3) The Activities

The activities were done in the schedule at Fonadhoo Education Centre, which is largest society in Fonadhoo Island. The scenes are shown in the following page.

1) Kick off and awarding (design competition for evacuation platform) ceremony
2) Presentation of Japan's experience- Disaster prevention preparedness at the primary school
3) Workshop for disaster prevention education for students and teachers

4) Feedback meeting with the teachers

Coordination meeting with Atoll and Island Chiefs

Coordination meeting with the principal of Fonadhoo Education Centre

Meeting with Women's Development Committee

Kick off and awarding (design competition) ceremony

Singing a song "O Ha Shi Mo" in Dhivehi

Awarding ceremony of the design competition

Tsunami Disaster Prevention workshop

Tsunami Disaster Prevention workshop (teachers)

12.3.5 Preparation of Documentary Video and Project Leaflet

A thirty minutes documentary video showing from the initial stage through completion of the project was prepared and edited in both Devihi version and English version. Also, a project leaflet was prepared for the public relations under reviewing by the authorities concerned.

12.4 Supervision of the Project

12.4.1 Meetings and Reports

The implementing organization, the Recovery and Disaster Risk Management Unit, held weekly meetings with the Study Team to discuss the progress and problems in the activities. The Unit and the Study Team prepared the activity reports showing updated situations of the project in weekly basis. The accomplishments with the figure and photos of the activities were included in the each report. The reports were kept in the Island Office for their record and sent to Laamu Atoll Office, MOAD, MPND, NDMC and DER/MFA for their information.

12.4.2 Participation of the Community

The followings are a summary of the participants in the project.

Table 12.4 Summary of the Participants in the Project

Type of Work	Participants(Man-day)			
	Baraasil	Medhuavah	Kurigamu	Total
Clearance of disaster wastes, sorting and processing of debris	748	1,474	488	2,710
Production of recycled Blocks	661	978	285	1,924
Management by the Unit	129	376	0	505
Watchmen	140	280	0	420
TOTAL	1,678	3,108	773	5,559

Note; as of 18th January 2006.

12.4.3 Provision of Facilities, Equipment/tools and Materials

Facilities, equipment/tools and materials for the activities during the project implementation are as follows:

Table 12.5 Provision of Facilities, Equipment / tools and Materials

Description	Quantity	Remarks
Facilities		
Platform/Monument (W=12m, H=2.6m)	1 unit	
Block Production Yard (30'x60')	1 unit	
Toilet, Generator Space and Storage (18.5'x26')	1 unit	
Equipment/Tools		
Wheel Barrow	20 units	
Mold (5"x6"x12")	60 units	
Shovel	40 nos.	
Weight (60kg)	1 unit	
Generator (7kw)	1 unit	
Bucket	10 nos.	
Trowel	15 nos.	
Air Pump	1 unit	
Clock	1 unit	
Other consumable tools	---	

12.4.4 Expenses for the Project Implementation

The costs for all activities in the project are shown below.

Table 12.6 Costs of the Project

Description	Amount (Rf)	Remarks
Lease of Equipment		
Concrete Mixer	10,500	
Welding Machine	16,500	
2 ton Pickup	56,345	
Subtotal	83,345	
Salary of Local Staff		
Salary	35,000	
Subtotal	35,000	
Labour Wages		
Clearance of Disaster Waste and Debris Recycling	713,650	Cash-for-work to the community
Construction of production yard	50,000	
Construction of platform/monument	702,990	
Construction of Toilet	75,700	
Subtotal	1,542,340	

Materials		
Block production for Platform/Monument	382,148	
Construction of production yard	127,992	
Construction of Toilet	95,382	
Others	32,343	
Subtotal	637,865	
Transportation of Equipment/Tools and Materials		
Materials for block production for Platform/Monument	196,800	
Materials for construction of production yard	32,295	
Generator	1,000	
Materials for Construction of Toilet	12,389	
Subtotal	242,484	
Insurance for the Activities		
Insurance	44,000	
Subtotal	44,000	
Workshop and Training		
Workshop and training	56,786	
Subtotal	56,786	
Purchase of Equipment		
Generator	78,619	
Subtotal	78,619	
TOTAL	2,720,439	

Note: Expenses are calculated based on the figures available on 10th February, 2006.

12.5 Monitoring of the Project

The project was designed for emergency relief towards Tsunami disaster in Laamu Fohandoo Island as a community's participatory project, and three components were included namely 1) clearing of disaster wastes and debris recycling, 2) building the Tsunami memorial and evacuation platform, and 3) disaster prevention preparedness. Third activity was carried out by JICA headquarters in collaboration with Japan's NGO and primary school teacher in Japan, while other two activities were done by the Study Team.

Upon termination of the project, the final monitoring was carried out with focus group interview and questionnaire survey (total 13 samples collected) in Laam Fonadhoo Island. DAC's project evaluation criteria (relevance, effectiveness, efficiency, impact, sustainability) that are also commonly used on JICA activities were applied to examine the project.

The project was commenced beginning of May 2005 and was terminated the middle of January 2006 in line with the schedule. In total approximately 5,559 man-day participated during the project period and cash-for-work generated approximately 1 million MRf. cash income to the

community. A total number of recycled block produced was approximately 38,400 blocks and JICA supplied necessary construction equipments and materials for clearing disaster waste and debris recycling, building Tsunami platform, which is 2.39 million MRf. including cash-for-work budget. The summary of cash-for-work is tabulated below.

Table 12.7 Summary of Cash-for-work(Debris sorting and recycling) in Fonadhoo Island

Item	Value	Remarks
Population	1,740	Statistics year 2000
Number of households	262	Statistics year 2000
Average household size	6.6	Persons/household
Total Labour force	799	Excluding foreign employee and employment outside of the island
Total project cost	2,388,994	JICA's finance
Total cash-for-work (MRf.)	1,010,500	JICA's finance
Income amount per capita (MRf.)	581	Total cash-for-work/ population
Income per labour force (MRf.)	1,265	Total labour force / disbursed amount per labour force
Income per household (MRf.)	3,857	Disbursed amount per person / Number of households
Total man-day of cash-for-work	5,559	Total man-day of cash-for-work
Total duration of participated person by labour force (days)	7	Total Person-day / total labour force
Total project input per capita	1,373	Total project cost / population

Source: JICA Study Team, MPND, Fonadhoo Island Office on December, 2005.

(1) Project's priority and needs (relevance) and effectiveness of the activities which leads the objectives

The project was finally implemented as the first recovery project in Fonadhoo Island as well as infrastructure recovery projects in Laam Atoll by Japanese Government except foods and goods donation by donors. The project covered one of the most damaged atolls and there was an administrative need as emergency recovery both in community and governmental levels.

The project brought emergency relief to the community partially especially cash-for-work generated additional household income to recover or repair damaged house or household goods by themselves. In addition, the project enhanced community's administrative empowerment towards natural disaster throughout the series of project activities such as establishment of implementation body, coordination among the community, implementation of activities, and so on. Thus, it pledges relevance with higher effectiveness of the project.

(2) Efficiency of timing, cost, and casual relationship among the project factors

It can be enumerated that the implementation body in addition to the inputs and the activity executed as it is a plan at first (There was partially a delay by changeable weather) was promptly set up based on an administrative office of the island and the existing community organization, and the talent arrangement was done appropriately as a contribution factor.

Moreover, it is one of effective contribution factors to carry out a transparent way that is to advance at first, and to have built an excellent interpersonal relationship based on the trust upon counterpart activities with the Study Team.

The monitoring was appropriately executed, and both parties have acted while sharing the target of the project as a partner. In the approach of technical support, the prototype of recycled block was made and it examined whether application was possible by the locale. in addition to that it examined a verification of strength as architectural materials, production quality by community workers, etc. Thus balance of the theory and practice was kept by having executed it after these technical supports made.

And, it was effective to attempt smooth recovery support by being able to do practicing guidance to the community through the project.

Moreover, it was high effectiveness that it was smoothly able to execute the project from planning to implementation stages consistently by the way of JICA Study Team operating directory. Consequently it was able to meet needs of emergency support promptly.

(3) Impact and sustainability of the project

The community had the initiative and acted from the establishment of the implementation body to the execution of the activities. This experience was accumulated in the community, and held the possibility of voluntarily developing it in the future.

It is recognized that the community based recovery project by the community participation accomplished the purpose for which it was originally intended enough. The participant received extraordinary income as a value of work by the project. And, the income generated by the project will become the foundation stone of reconstruction towards Tsunami damages.

In summary, the community learnt management know-how by the project and the process of manufacture of the recycling block was learnt. Construction equipments for producing recycle block, the yard, built platform and memorial granted to the project will be transferred to the community as it is. The community has an enough ability to manage these and use effectively

through the social empowerment generated by the project.