

THE STUDY  
ON  
COASTAL PROTECTION AND PORT IMPROVEMENT  
IN  
THE COOK ISLANDS

FINAL REPORT  
(EXECUTIVE SUMMARY)

AUGUST 1992

JAPAN INTERNATIONAL COOPERATION AGENCY  
(JICA)

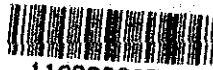
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## PREFACE

In response to a request from the Government of Cook Islands, the Government of Japan decided to conduct a study on Coastal Protection and Port Improvement and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cook Islands a study team headed by Mr. Mamoru Amemiya, Pacific Consultants International Co., Ltd., three times between October 1991 and March 1992.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of Cook Islands for their close cooperation extended to the team.

August 1992



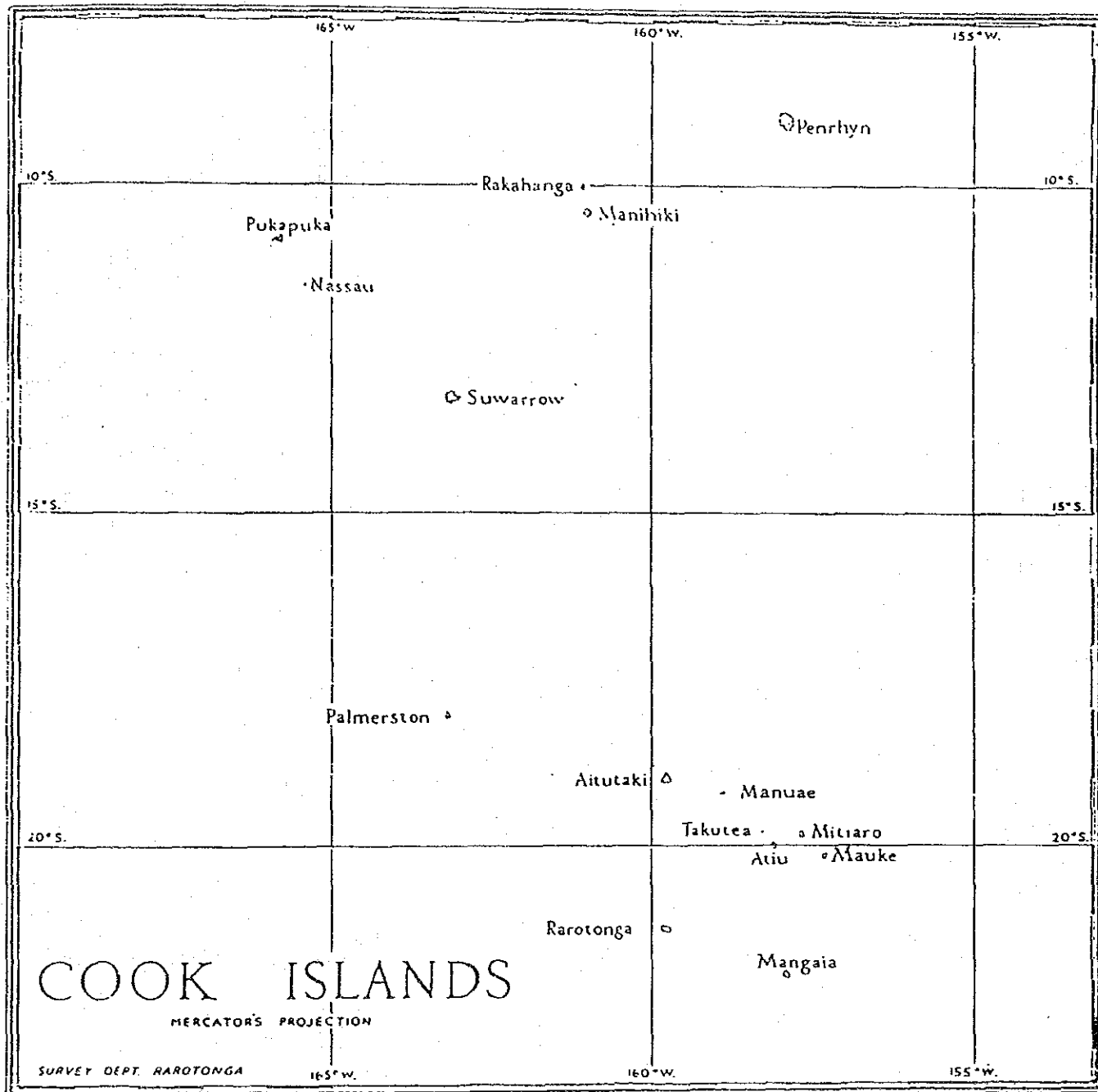
Kensuke Yanagiya

President

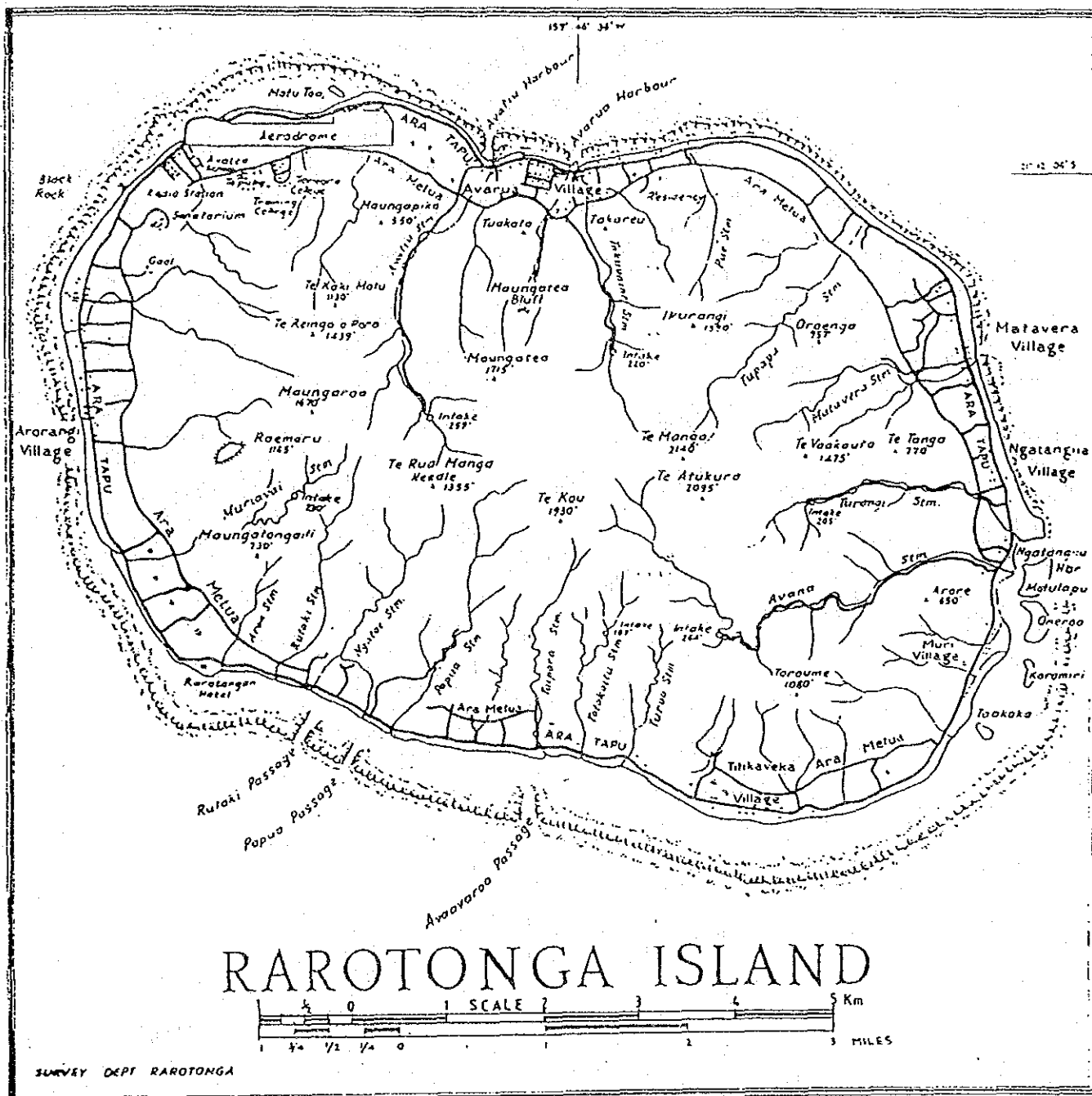
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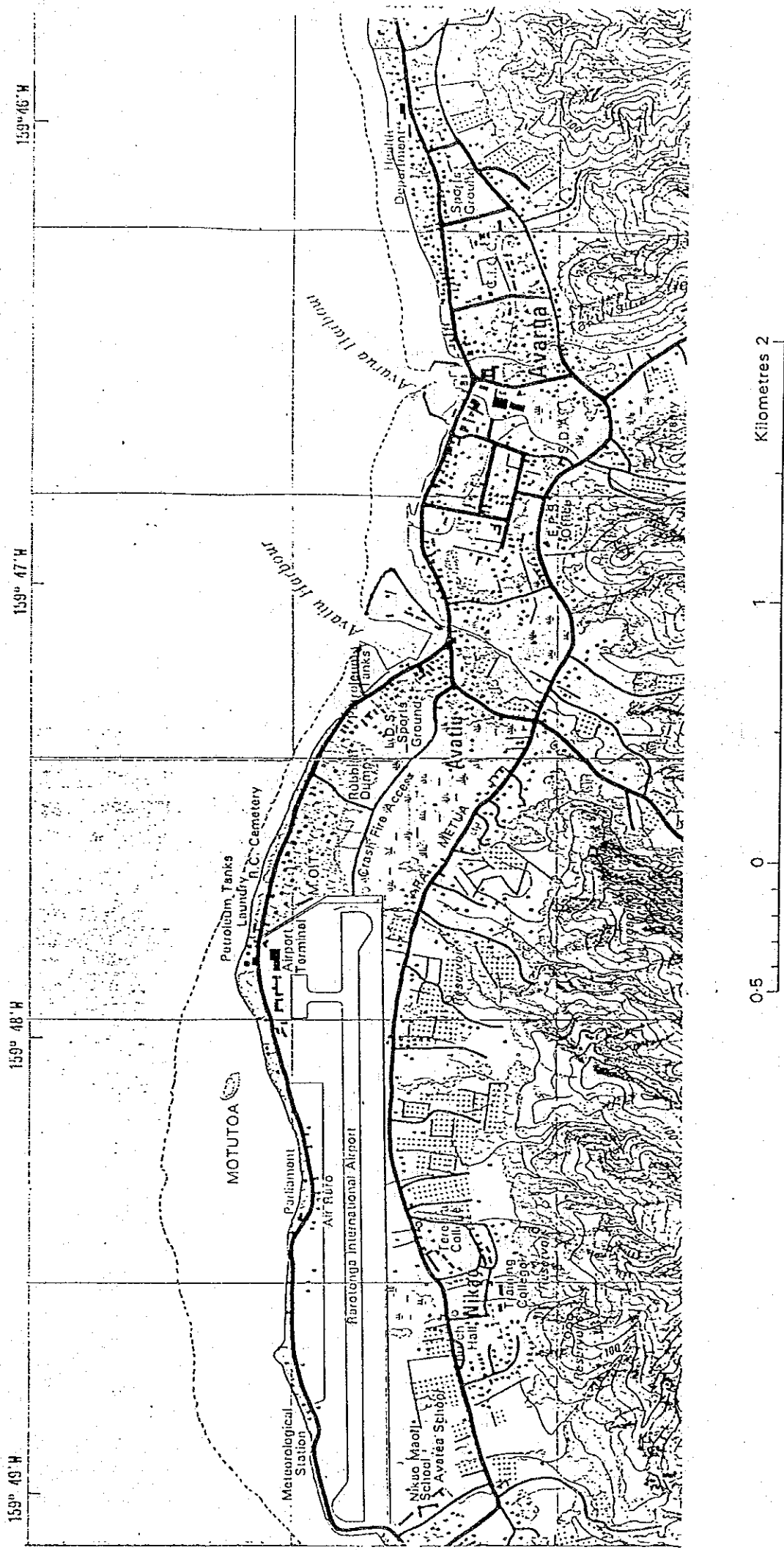














## CONCLUSION AND RECOMMENDATIONS





## CONCLUSION

### 1. Policy Objectives

The project is proposed based on the following policy objectives of the Government of Cook Islands.

- (1) Protection of the national land and the security of the nation against natural disasters.

The Cook Islands consists of 15 island situated from 156° - 167° west longitude to 8° - 23° south latitude.

Because of its location, the nation is attacked by cyclones every year and suffers heavy damage, such as coastal erosion. This is especially so on Rarotonga Island where the population is concentrated. Consequently, heavy damage is inflicted on commercial and business facilities, the airport, port and roads during cyclones.

Of future concern are the electric cables, gas pipelines and water supply lines that are buried along the coast, and other public facilities such as schools and hospitals, that may be damaged if a strong cyclone strikes.

- (2) Maintaining a supply of items essential for human life and related fundamental items.

Rarotonga Island has the most important transportation foot-holds, such as the Rarotonga Airport and Avatiu Harbour. The transported materials include items essential for human life and related fundamental items.

Therefore, by protecting transport facilities and ensuring the safety of ship maneuvering, the nation's social and economic stability will be maintained.

- (3) Promotion of Industries

Future economic growth depends upon the promotion of industries in the various region by utilizing prevailing natural conditions.

Therefore, certain facilities, such as a marina, will be needed as the core of industry.

Moreover, because the basic purpose of a fishery is to supply food to inhabitants and tourists on the island, small craft mooring facilities and stock facilities are required.

(4) Increase Employment Opportunities and Prevent of Population Outflow

Because of the current shortage of employment opportunities, the labor force, especially the younger workers, have sought employment outside the country. The people have vague misgivings about future social-cultural development. To erase these misgivings, it will be necessary to increase employment opportunities and promote the growth of industries.

2. Master Plan Policies

The following general policies should be taken into consideration in the Master Plan for the coastal protection and port improvement of Rarotonga Island:

- (1) The scale of investment cost should be evaluated by comparing it with the benefits of the project. The priority of project components should be considered to obtain maximum investment efficiency.

- (2) Long-term policies for coastal protection and port improvement should be prepared. This policy should be conducted based on both the long-term land use plan and facility layout.

- (3) Encouragement to the industries should be taken into consideration. The mitigation of damage to public utilities including port, roads, power supply and water supply should be conducted. The tourism industry should be encouraged by the implementation of coastal protection work and port improvements.

- (4) Most of the daily consumer goods are imported through the gate port, Avatiu Harbour. The harbour should be maintained not only as a transport life line, but as a hub port to the remote islands.

- (5) Flexibility for future land use should be taken into account since existing available land for public use is so limited. New land should be generated by reclamation along the Avarua Coast.

- (6) The proposed system in the Master Plan should meet with the locality including natural conditions and material availability.
- (7) Since tourism is one of the leading industries, adverse environmental effects to the industry by the project should be minimized.
- (8) As staged development plan should be prepared by considering the priority of project components.

### 3. Initial Investment Cost for the Master Plan

The target year of Master Plan is 2010. The total initial investment cost is 60.89 million dollars: 27.99 million dollars in coastal protection and 33.10 million dollars in port improvement.

### 4. Coastal Protection Master Plan

Damage by Cyclone Sally amounted to 13 million dollars at current prices. Total expected coastal damage by cyclones over the next 30 years amounts to 120 million dollars. This is equivalent to damages caused by 9.3 Sally class cyclones.

Coasts to be protected as proposed in the Master Plan were selected under the following conditions.

- i. Coastlines having an expected wave over-topping of more than 2 meters
- ii. Coastlines with active erosion observed by the Conservation Department or villagers

Coastal protection work should be considered at the following seven coasts:

- a) The shoreline between the northeast corner at Village Matavera/Tupapa to the east end of the airport (8,750 meter long)
- b) West of the airport (760 meter long)
- c) The northwest shoreline (1,500 meters) at Villages Poloinu I.R. and Tokerau/Inave against coastal erosion. This area is immediately south of Black Rock where the lagoon width is the narrowest and is exposed to the northern direction from which larger waves approach.

- d) The southwest corner (880 meters) at Village Aroa against coastal erosion.
- e) The southwest shoreline (200 meters) at Village Vaimaanga against coastal erosion. This area faces Papua Passage.
- f) The southeast corner (1,170 meters) at Villages Akapuao and Tikioki against beach erosion.
- g) The east coast (1,690 meters in total) at Villages Areite, Nukupure, Aroko and Avana. The shoreline (920 meters) at the first three villages requires countermeasures against beach erosion. The remaining 770 m at Avana coast requires countermeasures against coastal erosion.

Of these, 5,468 m of coastlines were finally selected for protection areas in the Master Plan. The existing land use behind the proposed coasts and the total project costs should be evaluated carefully.

- Urbanized area in Avarua	870 m
- Rural areas	4,178 m
- Tourism areas	420 m
Total	5,468 m

Avarua coast should be reclaimed as a buffer zone against cyclone wave overtopping and new public spaces. This area, named the Port Park Complex, should be utilized for road, car park, park and port expansion area. Coastal protection work at Avarua should harmonize with the proposed improvement work for two harbours. The east breakwaters for both harbours should be lengthened to ensure a required wave calm condition.

The breakwater arrangements should be prerequisite for both port improvement and coastal protection.

## 5. Port Improvement Master Plan

The primary objective of port improvement should be to provide proper port facilities and maintain a gateport to the island. This is essential to the people and various industries here. There is no other alternative than to improve the existing two ports located along the northern coast of the island.

Following are the proposed ideas for improving both Avatiu and Avarua Harbours:

- a) To provide a container storage area to accommodate the increase in container cargoes.
- b) To expand the east breakwater, the width of the entrance channel, turning basin and depth of the quay wall and the basin at Avatiu Harbour to ensure the safety of large vessels.
- c) To repair the existing quay wall.
- d) To prepare the facilities of the fishery port for the increase in both number and size of fishing boats to realize more fish catch.
- e) To construct a marina for the increase in the number of pleasure boats, especially large yachts to enhance tourism industry development.
- f) To protect small fishing boats from high waves during a cyclone.

Estimated cargo volume, fish catch, number of vessels for both harbours are as follows:

Demands	Short-term	Master Plan
	Year 1997	Year 2010
Trade cargo (Import)	46,400 FT	54,200 FT
Container	1,390 TEU	1,730 TEU
Domestic Cargo	2,400 FT	2,800 FT
Fish catch	150 MT	200 MT
Calling vessels per year		
- General cargo vessels	40	50
- Tankers	14	16
- Pleasure boats	190	340
Required berths		
- Pleasure boats	33	60
- Fishing boats	35	50

Note: FT = Freight Ton, 1 TEU = 15 Freight Ton  
MT = Metric Ton

The required functions at Avatiu and Avarua Harbours are commercial port, fishery port and marina. Function allocation among the two ports should be as follows:

Avatiu Harbour-----	Commercial port and Fishery
Avarua Harbour-----	Marina

The fishery sector should be located at the west basin of Avatiu Harbour.

The berth occupancy rate of the deep-sea berths for foreign trade in 2010 is anticipated to be about 31.3 percent. Thus, no additional berth for the trade needs to be constructed. The existing berth depth of -6.2 m should be deepened to -7.5 m for large vessels.

The width of the turning basin should be at least 140 m.

The present transit sheds in Avatiu Harbour do not need to be expanded. The required CFS area is smaller than the present area; thus no change may be required in the Master Plan. The container storage area (6,800 m<sup>2</sup>) and marshalling area (5,100 m<sup>2</sup>) should be maintained.

Cargo handling equipment in Avatiu Harbour should be improved as follows:

- |                      |                    |
|----------------------|--------------------|
| - Container          | , 5 Forklifts      |
|                      | 2 Tractor-trailers |
| - Conventional cargo | , 8 Forklifts      |

The fishery sector in Avatiu Harbour should be provided with a 230 m long wharf for landing and lay-by purposes. Sorting facilities and an ice making plant should also be provided.

The east breakwater in Avatiu Harbour should be lengthened to ensure a long stopping distance as well as wave calmness over 97 %.

Avarua Harbour should be redeveloped for a marina where a 380 m long wharf should be provided for 60 pleasure boats berthing. The east breakwater in Avarua Harbour should also be lengthened to protect small pleasure boats against prevailing easterly waves.

## 6. Initial Investment Cost of Short-term Plan and its Evaluation

The target year for the Short-term Development is 1997. The Short-term Plan should consist of high priority components among the Master Plan Development. The total initial investment cost amounts to 21.26 million dollars.

- |                      |                       |
|----------------------|-----------------------|
| - Coastal Protection | 8.46 million dollars  |
| - Port Improvement   | 12.80 million dollars |

According to the economic analysis, an economic internal rate of return (EIRR) is 10.7 %. Taking the important role of the project in the national economy into consideration, this project should be given the highest priority towards its implementation.

A financial analysis for the port improvement elements was conducted. According to the analysis, a financial internal rate of return (FIRR) is 3.9 % subject to the following two conditions:

- i. The operation and maintenance cost is decreased to 60 % or less than the current state.
- ii. The present port tariff is raised by 50 % to obtain a sufficient return.

Both TLT and WFC are requested to conduct further austerity measures for a stable port account.

## 7. Outline of the Short-term Development

- (1) To protect the national land and to ensure the nation's safety, appropriate coastal protection will be undertaken in the project.  
The area to be protected is the coastline since public utilities, such as the airport and port as well as the city environs, are in close proximity to the coast.
- (2) To provide coastal protection works in respect to natural disasters by wave over-topping and coastal erosion. The location to be protected will be selected based on past damage and land use requirements at its hinterland.

(3) To cover the damaged areas by coastal protection work.

- Coastal area near the Health Department and its surroundings
- Coastal area in front of the Avarua urbanized area
- Coastal area in front of the fuel storage yards at the eastern end of the existing airport
- Beach road near the MET
- Beach road at the northwest corner of the airport
- Beach road at the west end of the airport

Cyclones Val/Wase and Gene as well as Sally should be taken into consideration when preparing the protection plan.

(4) To maintain an adequate supply of items essential for life and related fundamental items.

The improvement of breakwaters, the basin and wharfs, and the procurement of a tugboat in Avatiu Harbour will be undertaken to minimize damage to the port caused by cyclones and to ensure the safety of ships maneuvering.

Additionally, to enhance physical distribution, the procurement of necessary cargo handling equipment is also considered in the project.

(5) To establish and promote industries, such as tourism, the improvement of breakwaters, the basin and the wharf in Avarua Harbour which is used for regular mooring and emergency evacuation of small fishing crafts.

(6) To create both comfortable and safety circumstances, a port-park complex in the Avarua central coast that will function not only as a green zone and parking area but also as a cyclone buffer zone will be established.

(7) To supply food to the nation's people and to tourists, fishery related facilities in Avatiu Harbour will be established.

(8) By promoting industries and, through the implementation of the project, employment opportunities and the number of permanent residents will increase.

(9) The aim of the above measures is towards the realization of land protection, the safety of the nation, and a stabilized national economy.



## 8. Total Evaluation

Based on the above, the project can be considered to be in harmony with the policy objectives of the Cook Islands Government.

Furthermore, if the current situation remains unchanged, there is a strong likelihood that heavy damage will be inflicted in the near future. Therefore, given that the primary aim of the project is to protect the national land and to defend it against natural disasters, the urgency of the project should be recognized.

It is concluded that the Short-term Development Plan is feasible.

## RECOMMENDATIONS

The recommendations below concern matters noticed while conducting this study and drafting the plans.

### 1. Action requested of the Cook Islands Government

The government is requested respectfully to pay special attention to the following for the meaningful implementation of the proposed coastal protection and port improvement at Rarotonga Island:

- (1) The basic land use plan should be prepared orderly to meet the island's development policy. In order to meet future demands, a public space at the Avarua urbanized area should be retained.
- (2) It is recommended that the coastal protection work conducted by MOW at the Avarua Coast and the surrounding coastlines be expanded.
- (3) The present distribution of building codes to villagers should be maintained. MOW should give an appropriate advice to villagers to ensure that their facilities are durable enough to withstand cyclones.

In respect to land ownership, the rights of tenants might gradually be strengthened.

- (4) To reduce overhead and enhance port operation and management, the establishment of a port authority is strongly recommended.
- (5) The existing LPG and fuel storage facilities at the center of Avatiu Harbour should be relocated to an appropriate site.
- (6) Dredged sandy materials in the port basin should be used for the nourishment of beaches where erosion is critical.
- (7) Prohibition of sand digging should be maintained.
- (8) MOW should continue its efforts to establish a new quarry to meet rock demands during the Short-term Development. Rocks should be the main materials for coastal protection work; it is cheaper than concrete.

(9) Utility mains, including water supply and power supply, along the damaged coastal areas should be relocated to a safety site.

(10) Road pavement at the northwest corner of the existing airport should be strengthened by concrete instead of asphalt.

## 2. Respect to Villagers Perception

One third of villagers understand that cyclone disaster here is the natural disaster. However the other one third believe that coastal protection work conducted in the past is not sufficient.

Villagers' requests to the coastal protection are to plant trees along the coastal bank, to prohibit sand mining and to construct such protection structures as seawall.

The government is strongly requested to pursue coastal protection work by taking villagers' desires into consideration.

## 3. Development Circumstances

By covering the entire the island coastline, this project may have various impacts. Since the proposed work should be concentrated along the coastlines where existing major developments are located, it is essential for the smooth construction to maintain the villagers' cooperation and understanding of the project.

Development of the coastal areas can be achieved once the general circumstances are improved. The most important step is to let villagers participate in project preparation. To carry this out, the best effort to improve the villagers' consensus of the project should be made by the government.

(1) For better understanding of the project, a basic planning process should be disclosed to the villagers.

(2) For better agreement on the project, the final layout together with alternatives should be provided to the villagers.

- (3) Data and information relating to the utilization of coastal areas and the possible effects of cyclones should be published and made available to the villagers and to industries.

a) Coast File

Available information should be kept on file as permanent records. The file shall include the physical characteristic and existing land use of each section of coast. This file may provide the people with an opportunity to learn about their coast.

b) Coastal Disaster Forecast

Possible disasters by cyclone waves and surges should be shown on a map and distributed to the public.

- (4) The government can not share all the responsibility for cyclone disasters. The budget is normally limited in any country, thus budget allocation to the project shall be carried out to selected projects having the highest priorities based on real demands. It is recommended that the private sector should do its best to protect their property from cyclone damage. The private sector should not locate their properties in high risk areas. The government may provide protection work at danger areas if damage cannot be prevented through the efforts of the private sector.

The government should locate their new property in safe places and should provide protection measures for the existing facilities located in danger zones. For project economy, relocation of existing facilities to safety zones may be a possible choice. MOW is requested to take the initiative in this matter.

- (5) The Conservation Department should play a role in controlling the ordinary development of specified coastal areas. The monitoring of the coastal areas should be maintained. The department should provide villagers with a proper explanation of benefits of coastal conservation.
- (6) A project executing agency should be established for smooth project implementation. Financial assistance, if so required, should be considered by the government for better maintenance efforts.

#### 4. Preparation for Project Implementation

For smooth project implementation and its fruitful completion, the government should make necessary preparations.

##### (1) Administrative Aspects

It is recommended that an organization for the project implementation be established. Since the project covers various technical fields, participation by related governmental agencies will be needed. The project will be managed by a project executing agency under the multi-discipline task force (MDT) which may consist of representatives from related agencies.

##### (2) Technical Aspects

The executing agency should manage the detailed design of project components together with the preparation of Tender Documents. The agency should also manage construction supervision.

At present, there is no firm city master plan for the Avarua Urbanized Area. The utilization of the new reclamation area, including the Port Park Complex, should meet the proposed concept regarding city planning. MOW may be the leading ministry for this task. Other public sectors and private sectors should also participate in this arrangement. Since it faces the open sea, the newly reclaimed area is not only used as a cyclone buffer zone but also for improving land resources. The maximum utilization of this land should be performed accordingly.

##### (3) Financial Aspects

The proposed Short-term Development Plan will cost about 21.26 million Cook dollars: 8.46 million for coastal protection and 12.80 million for port improvement. It will take about three years to complete the construction work. Thus, approximately seven million Cook dollars should be paid to the contractor each year.

If the government intends to obtain financial assistance from an external monetary source, necessary arrangements should be made to meet the construction schedule.

## 5. Consideration to Better Environment

It is important to remember that tourism industries here are simply based on natural resources. Within certain limits, nature has the power to recover from adverse environmental impacts. If the impacts override this natural sustaining capacity, the ecosystem will gradually change. The costs required for maintaining the present ecosystem could be much lower than that for recovering the environment after being severely damaged.

To maintain sustainable environmental conditions, it is recommended that continuous efforts be made to provide coastal areas with a better future environment. Necessary action to be taken by the government are as follows:

### (1) Investigation and Monitoring

It is recommended that periodical investigations be made of the seawater quality including, BOD, COD, HP and coliform bacteria. It is also recommended that environmental standards be established by which surveyed data can be evaluated.

### (2) Enforcement

It is reported that the Conservation Department is preparing water quality regulations that will require the private sector to provide their own septic tanks if they are located within thirty meters of the high water mark.

It is also recommended that large-scale coastal developments be assessed to minimize environmental impacts that may severely damage the existing environmental conditions and that measures to mitigate the impacts be instituted.

### (3) Advertising

At present, the island environment is generally good. It is, however, recommended that necessary information be passed on to the villagers so that they can understand the importance of maintaining and protecting the environment.

Foreign Exchange Rate

1.00 Cook Dollar = 1.00 NZDollar = 69.1 Japanese Yen

(as of January 1992)

Currency used in this report is the Cook Dollar otherwise noted.





# Final Report Executive Summary

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## Chapter 1: Introduction



## **Chapter 1 Introduction**

### **1.1 Background of the Study**

Avarua-Avatiu Area of Rarotonga Island is the socio-economic center of the Cook Islands. Avarua and Avatiu Harbours are the hub ports in terms of trade and domestic marine transport of the Islands. These areas have suffered a lot of damage by wave run-up and flooding due to waves surges.

Since the damage by Cyclone Sally in 1987 was quite severe, the Government of Japan provided the Islands with a grant aid and dispatched an expert team three times. The team recommended an integrated coastal protection plan together with the port improvement of Avarua and Avatiu Harbours, based on the discussion between the Cook Islands Government and the team as the result of site investigation.

In April 1990, the Cook Islands Government requested the Government of Japan for a technical assistance regarding the port improvement of Avarua and Avatiu Harbours and the coastal protection of Rarotonga Island. In response to this request, JICA dispatched a preliminary investigation team and concluded the Scope of Work.

Subsequent to the signed Scope of Work, a JICA a study team was dispatched in October 1991 and commenced the study. The Final Report was completed by the end of August 1992.

### **1.2 Objectives of the Study**

The objectives of the Study are to carry out the data analysis and the preparation of phased development on coastal protection and port improvement at Rarotonga Island from both the technical and economic points of view. Rorotonga is a circular shaped island having a 31 km long shoreline. It is located in the southern Pacific Ocean at a latitude of 21°S in the region of the Tropic of Capricorn. Unfortunately, the island is located on a main route taken by cyclones. Every five years a large scale cyclone (wave height in 6.5 m or larger) passes near the island and causes extensive damage to the island's nature and property.

The government has exerted its best efforts to mitigate cyclone disasters. This includes preliminary coastal area conservation control, structural

improvement of private housing, control of beach sand digging and provision of coastal protection work together with breakwaters at two major harbours.

The main target in this study is the high seas generated by air turbulent due to a low atmospheric pressure, the cyclone. At first; it generates a strong gale which creates waves and secondly make happen of high tide. Additionally, wave set-up resulting from the concentration of wave energy in the shoal water may occur in the lagoon. All of these tend to take place whenever a large wave breaks over the reef and into the lagoon.

In 1987, Sally made a large impact on islanders not only as a result of the damage done to their properties but also in realizing the tremendous power of a cyclone when it hits the coastal areas. According to the damage records of Sally prepared by MOW and the Conservation Office, high seas attacked the northern beaches of the island causing beach erosion, and in many places, the run-up of water bodies containing coral rocks. These effects have been well observed at the Avarua and Avatiu areas and their adjacencies.

Thus, the main objective of the Study is to prepare the Master Plan of coastal protection showing the necessary action to be taken by the private and public sectors. The feasibility study should be conducted for preparing the more detailed action plans for the most densely urbanized area, Avarua and Avatiu areas and their adjacencies.

The Avarua area is the center of Rarotonga, the capital of the Cook Islands, where the nation's major political and economical activities takes place. Furthermore, Avarua and Avatiu Ports also play major roles in the country's sea communications.

The Avarua area is therefore a target of this detailed analysis. Since these two ports are located in the midst of the urbanized area, the necessary action to be taken by them in the future are also studied and combined with the coastal protection works.



### 1.3 Scope of the Study

#### 1.3.1 Study Areas

##### Area for the Master Plan

##### 1) Coastal Protection

The Master Plan of the coastal protection should cover the entire coastline of the island as a long-term development plan for the year 2010. Table 4-1 shows the constituencies and the names of the villages on Rarotonga Island. The total shoreline length shown in the Table is 30,990 meter. There are fifty one villages under seven constituencies. Among them, forty seven villages are exposed to the open ocean. The average shoreline length per coastal village is about 660 meter.

##### 2) Port Improvement

As shown in the agreement, the Master Plan of the port improvement should cover the two existing ports, Avatiu and Avarua, as a long-term port development plan for the year 2010. Land use of ports will be expanded to adjacent areas to meet further land requirements in future. Avatiu is a fully development port and currently occupies a 500 meter long coastline, while Avarua is a port under construction and occupies coastline that is about 300 meter long.

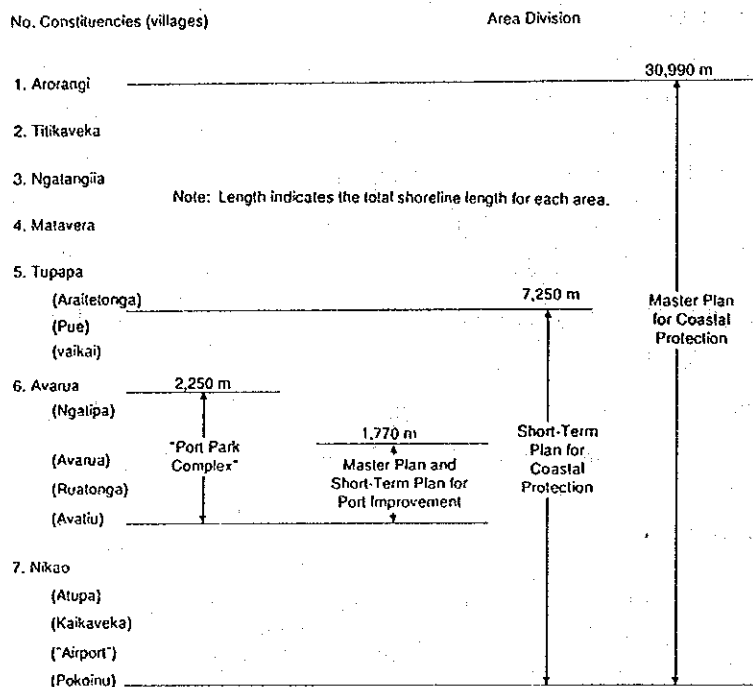
##### Areas for the Short-term Development Plan

##### 1) Coastal Protection

The Short-term Development Plan will cover the Avarua coastal area with its surroundings including the existing airport area and the Avarua eastern coast up to the Health Department where urgent protection work may be required by the year 1997. Among the areas covered by the Short-term Development Plan, new reclamation work will be conducted at the Avarua coast as a buffer zone against waves and surges and will be named as the Port Park Complex. This area will be utilized not only for the coastal protection but also for various public uses including port expansion.

## 2) Port Improvement

Based on the proposed Master Plan, the Short-term Development Plan for port improvement will cover only urgent improvement works will be required for two ports by the year 1997.



### 1.3.2 Content of Study

The study shall cover the following items:

- 1) Collection, review and analysis of the existing data, information, and reports relevant to the Study
- 2) Undertaking of Site Surveys for the Study
- 3) Preparation of the Master Plan for the period up to the year 2010
  - Master Plan for the coastal conservation of the Rarotonga Island
  - Master Plan for the improvements to the Avarua-Avatiu port area
- 4) Undertaking of the Feasibility Study for the period up to the year 1997
  - Coastal protection plan for the coasts adjacent to the Avarua area
  - Port improvement plan of the Port Area
- 5) Preparation of Conclusion and Recommendations

#### **1.4 Composition of Reports**

The Final Report consists of two volumes, namely Volume I "Master Plan" and Volume II "Short-term Development Plan" based on feasibility study. Then, all the conclusions and recommendations for the project including countermeasures on the comments were included in the Final Report.

#### **1.5 Site Visit and Activities by the Study Team**

The first site visit was conducted by the team from the middle of October to the end of November, 1991. The team met and exchanged opinions with the project steering committee of the Ministry of Planning and Economic Development, MOPED, on the behalf of government. The team left the island for Tokyo 24 November, 1991. Immediately after returning to their home offices in Tokyo, the team reported major happenings on the island to the JICA supervisory committee and then commenced the study for the interim report.

Second Visit was made from the end of January to the middle of February, 1992. The team submitted the Interim Report to the government and conducted discussion on recommendation and findings in the said report. On the way back to Tokyo, they dropped at the Japanese Embassy in Wellington and reported the results of discussion in the island. Immediately after arriving at Tokyo, the team reported also happenings in the island to the JICA supervisory committee and commenced the study for the preparation of Draft Final Report.

Submission of the Draft Final Report and discussion of it with the committee was undertaken by the team in the middle of March, 1992. The team submitted the Draft Final Report, Volume I and Volume II to the government for discussion on the 12th of March.

The team left the island for Tokyo on the 23rd of March, 1992. On the way back to Tokyo, they dropped at the Japanese Embassy in Wellington and reported the results of discussion in the island. Immediately after arriving at Tokyo, the team commenced the study again for the preparation of Final Report.

On the 27th of April, 1992, the study team received the comments on the Draft Final Report and commenced the preparation of Final Report. The Final Report was completed by the end of August 1992.

## 1.6 Organization of the Study Team

The study team is comprised of seven experts from OCDI and PCI. Their names and responsibilities are as follows.

Mamoru Amemiya	Leader	Pacific Consultants International (PCI)
Tomoo Amano	Port Planning	Overseas Coastal Area Development Institute of Japan (OCDI)
Eiji Kawabata	Coastal Planning	PCI
Hiroshi Kayukawa	Demand Forecast/ Economic Analysis	OCDI
Masato Suzuki	Design/Construction/ Estimation	PCI
Yutaka Yoshimori	Operation/Management	OCDI
Mitsuhiko Hasegawa	Natural Condition	PCI

## 1.7 Members of the Steering Committee

The members of the Steering Committee of Cook Islands Government are listed below.

Mr. Richard Chapman	CHAIRMAN	Acting Secretary Ministry of Planning and Economic Development (MOPED)
Mr. Tai Manuela		Director of Planning and Programmes

Mr. Tap Pryor	Ministry of Planning and Economic Development
	Chief Project Officer
	Ministry of Planning and Economic Development (MOPED)
Mr. Brent Dark	Development Economist
	Ministry of Planning and Economic Development
Mr. George Cowan	Secretary
	Ministry of Works
Mr. Henry Puna	Secretary
	Ministry of Trade Labour and Transport (TLT)
Mr. Ata Herman	Harbour Engineer
	Department of Trade, Labour and Transport (TLT)
Mr. Vaitoti Tupa	Deputy Director of Conservation Service
Mr. Oliver Peyroux	Chief Surveyor
	Survey Department
Mr. Don Dorrell	Coastal Consultant to the Prime Minister on Coastal Protection
Mr. Patana Yala	Chief Resident Engineer Ministry of Works



## Chapter 2: Methodology





## Chapter 2 Methodology

### 2.1 Workflow Diagram and Work Schedule

The work schedule is shown in Fig. 2-1. The agreed workflow diagram is shown in Fig.2-2. From the diagram it can be seen that the work can be divided into seven stages. There are 29 work components, the highlights of which are summarized in Table 2-1.

Fig. 2-1 Study Schedule

Work items by Stage	Year		1991				1992							
	Month		S	O	N	D	J	F	M	A	M	J	J	A
Stage 1 Preparatory Work				—										
Stage 2 Field Survey				Δ IC/R										
Stage 3 Master Plan for the year 2010						—								
Stage 4 Submission of Interim Report							Δ IT/R							
Stage 5 Feasibility Study for the year 1997								—						
Stage 6 Submission of Draft Finan Report									Δ DF/R					
Stage 7 Finalization														Δ F/R

Legend: — Preparation, — Work in Cook Islands, — Work in Japan

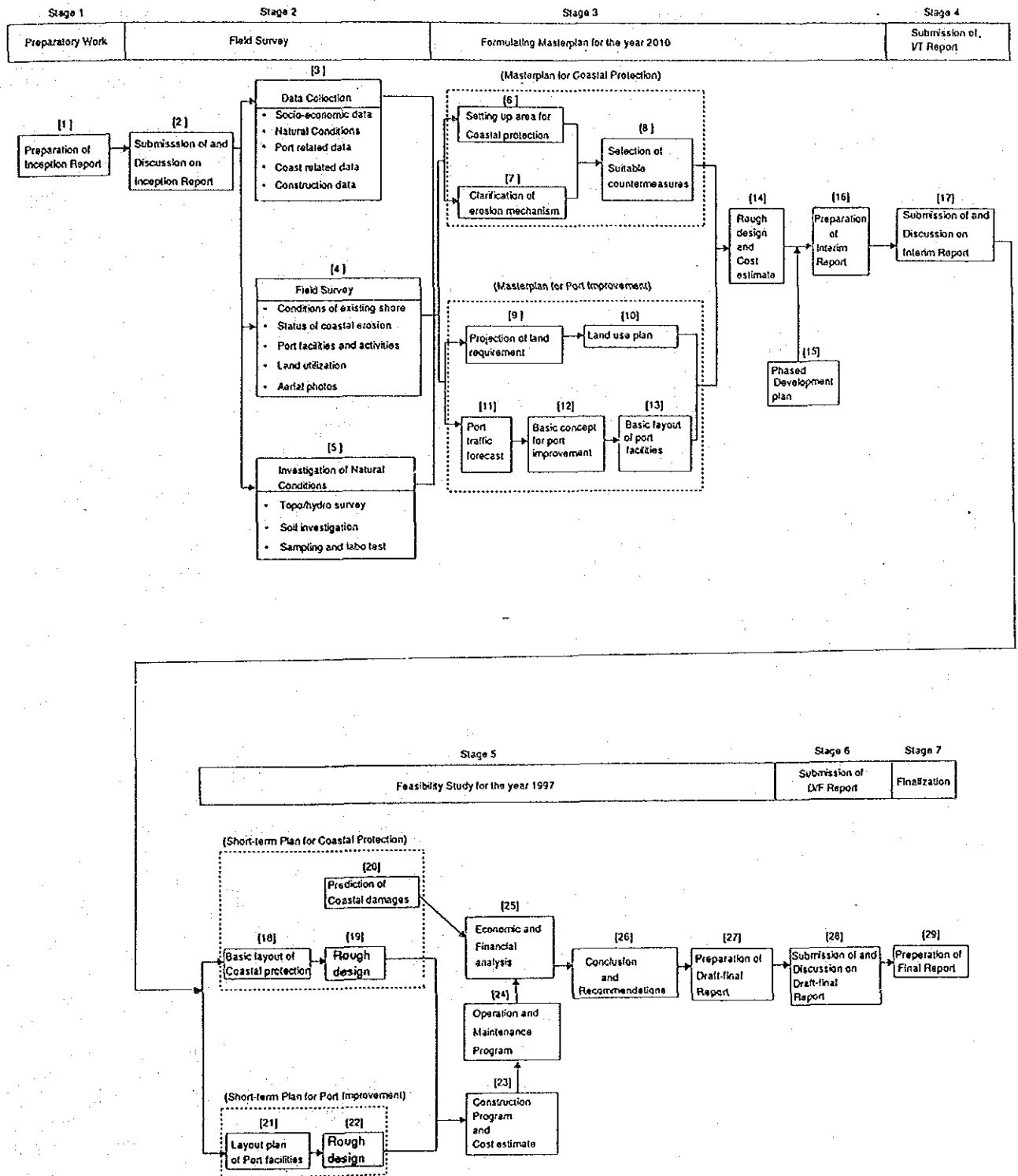
Note. The study team received comments on the Draft Final Report at the end of April, 1992. Explanatory Notes outlining the Final Report and countermeasures to comments was submitted to the Cook Islands Government prior to the submission of Final Report. Thus, completion of report was completed at the end of August, 1992.

Table. 2-1 List of Work Components

Stage	Main Target	Step	Work Components
<u>Stage 1</u>	Preparatory Work	(1)	Preparation of Inception Report
<u>Stage 2</u>	Field Survey	(2)	Submission of and discussion on the report
			↓
		(3)	Data collection
		(4)	Field survey
		(5)	Investigation of natural conditions
Stage 3	Formulation of Master Plan for the year 2010		[Master Plan for coastal protection]
		(6)	Setting up area for coastal protection
		(7)	Clarification of erosion mechanism
		(8)	Selection of suitable countermeasures
			[Master Plan for port improvement]
		(9)	Projection of land requirement
		(10)	Land use plan
		(11)	Port traffic forecasts
		(12)	Basic concept for port improvement
		(13)	Basic layout of port facilities
			[Integration ]
		(14)	Rough design and cost estimates
		(15)	Phased development plan
		(16)	Preparation of Interim Report
Stage 4	Submission of Interim Report	(17)	Submission of the report
Stage 5	Feasibility Study for the year 1997		[Short-term Plan for coastal protection]
		(18)	Basic layout of coastal protection
		(19)	Rough design
		(20)	Prediction of coastal damages
			[Short-term plan for port improvement]
		(21)	Layout plan of port improvement,
		(22)	Rough design
			[Integration ]
		(23)	Construction program and cost estimates
		(24)	Operation and maintenance program
		(25)	Economic and financial analysis
		(26)	Conclusion and Recommendations
		(27)	Preparation of Draft-Final Report
			↓
Stage 6	Submission of Draft Final Report	(28)	Submission of and discussion on Draft Final Report
			↓
Stage 7	Finalization	(29)	Preparation and submission of Final Report

Fig. 2.2 Work Flow Diagram

Work numbers below are corresponding with work component numbers in Table 2-1.





## Chapter 3: Socio-Economic Conditions



## **Chapter 3 Socio-Economic Conditions**

### **3.1 Major Economic Conditions**

Although information subdivided into the island area not available, discussion of these conditions will commence with indices in respect to the whole country since Rarotonga island is the core of national economy.

#### **3.1.1 Population**

The population of the Cook Islands grew steadily until 1971. From 1951 to 1971, an annual growth rate of around 2.1% was recorded. From 1971 to 1986, however, the population declined, especially from 1971 (peak) to 1976, when a 3.0% annual decline was experienced. The main reasons for the decline in population were the expansion of air services and the availability of employment opportunities in the New Zealand labour market. After 1976, the population declined at a very low rate; in recent years it has been relatively stable.

Rarotonga is the largest island and has the largest population in the country. The growth of population in Rarotonga has almost mirrored that of the country as a whole. The population has tended to concentrate here. About 55% of the population was concentrated here in 1986. The population in proportion to the rest of Southern and Northern Group was about 32% and 13% respectively in 1986. Cook Islands' population growth in the is shown in Fig. 3-1-1.

#### **3.1.2 Gross Domestic Product (GDP)**

The gross domestic product (GDP) in the Cook Islands has experienced continuous growth in both current and constant 1990 prices from 1982 to 1990 as shown in Fig. 3-1-2.

Fig. 3-1-1 Population Growth in the Cook Islands by Census Years  
Source: Statistics Office

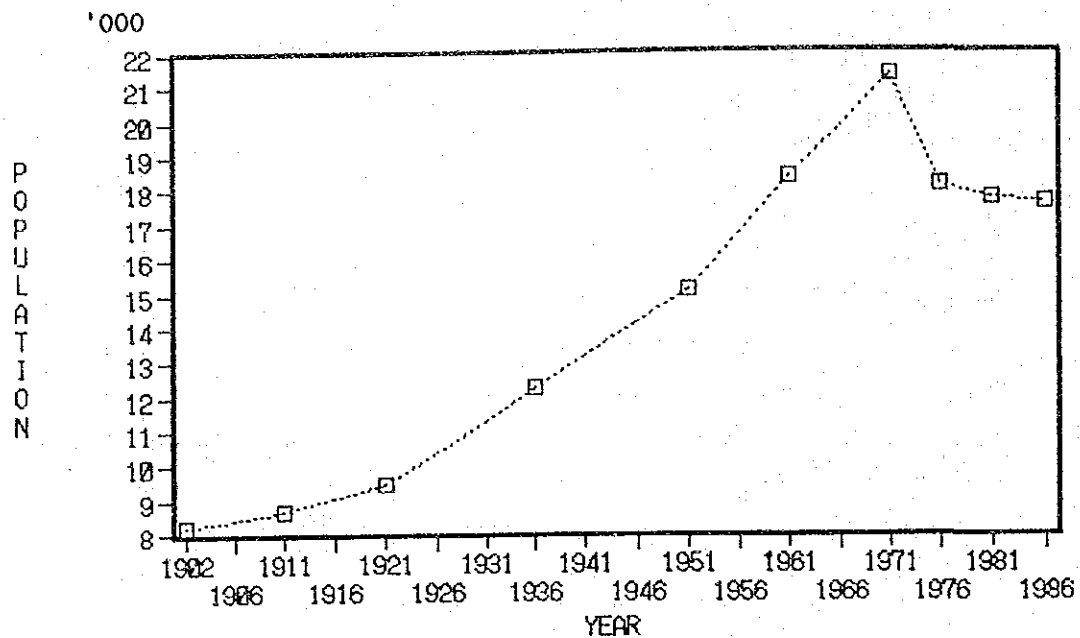
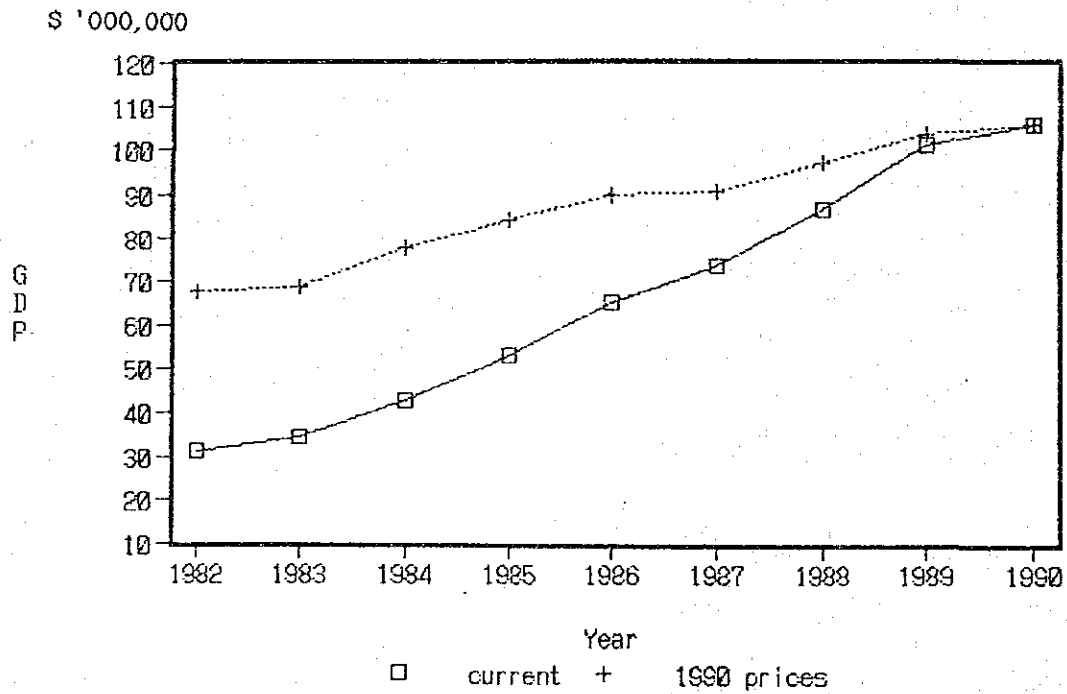


Fig. 3-1-2 GDP Current and 1990 Constant Prices from 1982 to 1990  
Source: MOPED, Statistics Office





The basic economic sectors are (i) agriculture and fishery, (ii) wholesale and retail trade, restaurant and accommodation, and (iii) public administration. These three sectors make a strong contribution to the economy in the Cook Islands. the share of agriculture and fishing, however, especially agriculture, is decreasing. The other two sectors have maintained their share in these years. The sector with the highest growth rate is the electricity and water sector, while the agriculture and fishing sector has the lowest growth rate.

### 3.1.3 Other Indices

#### 1) Expenditure of Cook Islanders

Total family expenditure at Rarotonga was \$ 3,876 million in 1987. Distribution of expenditures by major group is as follows.

Table 3-1-2 Distribution of Expenditures

Items	Distribution (%)
Foods and beverages	53
Housing and household	15
Clothing, footwear etc.	7
Medical care	3
Transport, recreation and communication	6
Education	6
Taxes and others	10

Source: MOPED, Statistics Office

#### 2) Price Increase and Inflation

The inflation rate in the last five years has averaged 7.7% annually, which constitutes a reduction compared to previous years. For the years 1967 to 1986, an average rate of 13.3% has been recorded; the lowest was 4.8% in 1970 and the highest was 24.1% in 1976.

## 3.2 Industries

### 3.2.1 Composition of Industries

The main industries in the Cook Islands are agriculture, tourism, manufacturing and fishery (marine resources).

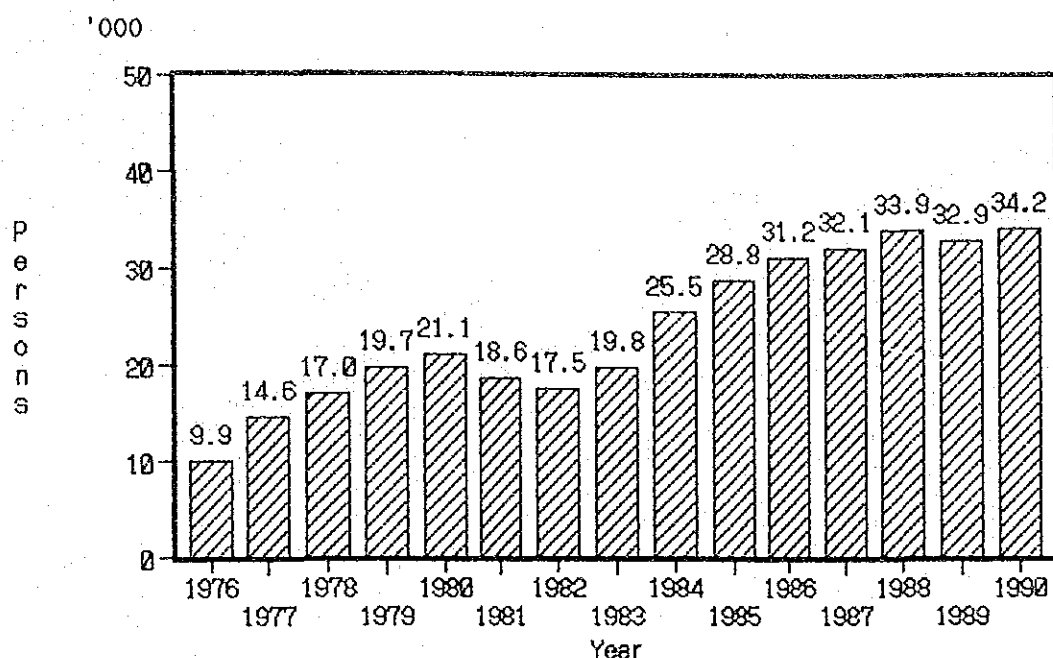
The leading sector identified to stimulate the economy growth in the Cook Islands is tourism. Agriculture is the main productive sector in the Cook Islands and will continue to contribute extensively to the economy of the country, particularly the outer islands. Although the performance has generally been poor, there is a potential for fishery (marine resources). In addition, large vein of manganic nodule was found within the economic territorial waters of the Cook Islands in 1989. Mining and other related industries will be able to commence operations sometime in far future.

### 3.2.2 Major Industries

#### 1) Tourism

Tourism has grown from the early 1970's to become the major foreign exchange earner and the principal force for economic growth in the Cook Islands. Tourism is also the largest export industry and provides more employment opportunities than any other single industry. Significant tourism in the Cook Islands began in 1974 following the completion of the Rarotonga Airport in 1973. Tourist arrivals from 1976 to 1990 are shown in Fig. 3-2-1. Approx. 34.2 thousands tourists visited in 1990, which represents an almost three and half times increase over that of 1976.

Fig. 3-2-1 Past Records of Tourist Arrivals (1976 ~ 1990, '000 persons)  
Source : Tourist Authority



## 2) Fishery (Marine Resources)

Marine resources play a significant role in the culture, and traditional an diet of the Cook Islanders.

Subsistence and artisanal fisheries are the main activities in the Cook Islands. Subsistence fishing provides the Cook Islanders with a significant proportion of the protein requirement. It includes the collection of shellfish and edible seaweed, reef-fishing and netting, free-dive and scuba spearfishing, handling for reef fish, trolling and dropling for tuna from canoes and small boats.

There were 234 imported open type fishing boats, 228 locally made and 52 for small commercial fishing and tourist activities in 1986. Since then, according to the Ministry of Marine Resources, the number of fishing boats is estimated to have more than doubled due to the increase in marine

activities such as the pearl industry in the Northern Group and fishing activities in other islands.

Although there has been limited development of the fishery industry so far, a high seas fishery industry for tuna and other migrant species within the vast Exclusive Economic Zone (EEZ) holds considerable potential for the future; in this respect, the development of fishing facilities will be urgently required in the Cook Islands.

## Chapter 4: Outline of Coastal Areas



## Chapter 4 Outline of Coastal Areas

### 4.1 Existing Land Use

#### 4.1.1 General View of Land Use

The island is located on the Tropic Capricorn and has a total area of about 75 square kilometers. About 68 % of the area is mountains covered by tropical forests and exposed volcanics. The highest mountain is Te Manga that is 653 meters above the datum, Mean Sea Level (MSL). The gradient of mountain slopes are relatively steep ( $30^\circ$  or more), and likely are unsuitable for development by human beings. Of course, this area has not been damaged by cyclone waves and surges.

Areas other than mountains consist of relatively flat topography, namely hills, marshes or wet lands and beach banks.

The hills actually form the skirts of the mountains, and range between +5.0 meters up to +30 meters above MSL, having an average slope gradient about three to six degrees. This area is utilized mainly for the agricultural development of fruit culture. Ara Metua, one of two main roads of island runs through the middle of this area. This hilly area shares about 16 percent (or 12 square kilometer) of island's total areas. These areas have not been damaged by cyclone waves and surges.

The marsh (or swamp) consisting of low wetlands with mud soil is 150 meters wide and is located between the hill and the beach banks. The average ground level ranges from +1.5 meters to +5 meters above MSL where the richest soil and active floras and faunas can be seen. It is 4.5 square kilometer and shares 6 percent of the total land. Use of the wetlands is relatively lower due to frequent flooding and limited accessibility.

The beach bank (or coastal area) is a 250 meter wide ring along the waterfront. It is 7.5 square kilometer in size and shares about 10 percent of the total land. The height of this land ranges between +1.5 meters to +7.5 meters above MSL.

The map depicts Rarotonga Island with its irregular coastline. Major roads are shown as solid lines, and smaller roads as dashed lines. Settlements are marked with dots and labels. Key locations include Avarua (the capital), Arorangi, Muri, and Mouturua. The map also shows the island's internal structure, including the central mountain range and the surrounding lagoon. A scale bar at the bottom left indicates a distance of 7.5 miles.



The shoreward area of this is the last sea defense line. The beach bank consists geotechnically of coral rock and coral sand including boulders. The surface of this area is generally covered by sandy earth. More than 70 percent of the total population currently inhabits this area. Most of the public facilities, such as schools, the hospital, churches, cemeteries, sport grounds and government offices are located here.

The private enterprises located here include shops, restaurants, a factory, fuel storage tanks, motels and hotels except for the Sheraton which is under construction in the hilly area and wetland at Village Vaimaanga. The beach main road, Ara Tapu, is the only access existing along the shoreline. Connecting accesses from Ara Tapu lead to Ara Metua. This area is the main target for providing appropriate coastal protection work.

#### 4.1.2 Villages

There are fifty one villages; forty-seven of them are directly exposed to the ocean. As shown in the Table, the total length of Ara Tapu as measured from the maps is 30,990 meters. The average shoreline length per village is 660 meters, and ranges from 2,560 meters for the "Village Airport" as the maximum length to 130 meters for Village Ruatonga as the minimum length. The Avarua constituency shares about 25.0% of population. This shows that the Avarua District together with its surroundings have the highest population density due to it being the most active place for industry, economy and culture.

Table 4-1 CONSTITUENCY AND VILLAGE OF RAROTONGA ISLAND

No.	Const/Village	Shore Length (m) (Road Length)	No.	Const/Village	Shore Length (m) (Road Length)
1.	Arorangi		4.	Matavera	
101	Pokoinu I Raro	900	401	Pouara	430
102	Tokerau/Inave	1,200	402	Vaenga	180
103	Arerenga	530	403	Matavera/Tupapa	1,400
104	Akaao	1,070	404	Titama	600
105	Vaiakura	700		Subtotal	2,610
106	Kavera	850			
107	Aroa	880	5.	Tupapa	
108	Rutaki	1,330	501	Araitetonga	700
	Subtotal	7,460	502	Kiikii	1,160
2.	Titikaveka		503	Punataia	160
201	Vaimaanga	1,530	504	Tapae	390
202	Avaavaroa	1,150	505	Tapae I Uta	0
203	Totokoitu	300	506	Pue	470
204	Turoa	600	507	Vaikai	250
205	Arakue	630		Subtotal	3,130
206	Kauare	400	6.	Avarua	
207	Titikaveka	300	601	Ngatipa	480
208	Te Puna	500	602	Tauae	0
209	Akapuao	770	603	Avarua	1,170
210	Tikioki	800	604	Ruatonga	130
211	Maii	700	605	Avatiu	470
	Subtotal	7,680		Subtotal	2,250
3.	Ngatangia		7.	Nikao	
301	Vaii	170	701	Atupa	520
302	Aremango	500	702	Kaikaveka	450
303	Areiti	300	703	"Airport"	2,560
304	Nukupure	310	704	Puapuaatu	0
305	Aroko	310	705	Nikao	0
306	Avana	770	706	Pokoinu	790
307	Ngati Vaikai	230		Subtotal	4,320
308	Ngati Maoate	150			
309	Ngati Au	230			
310	Turangi	570			
	Subtotal	3,540		Total Shore Length	30,990 m

Source : Study Team

## 4.2 Typical Cross Sections

### 1) Land use zone one: Established Urban Areas

The Avarua beach main road runs immediately behind the coastline. Shopping centers, restaurants, car rental services and street vendors are located along the road. Most of the government offices are located within one hundred meter landward. Public open space here is a narrow strip between the road and beach top, ranging from five to twenty meters.

### 2) Land use zone two: Rural Areas "A"

The beach road in this area runs within 30 meters landward from the beach top. The first 10 meter area is covered by flora. Architectural facilities are located behind the road. Public spaces such as hospitals, sports grounds and schools are often developed behind the road. According to the government agencies, utilities, such as water supply and power distribution mains are embedded under the road shoulder shoreward. Most of the local shops and restaurants are located along the road. In some areas the road runs just along the beach.

### 3) Land use zone three: Tourism Development Areas

Land composition of this zone is similar to zones two or four except for the following:

- a) The space between the beach and the road is occupied by private enterprises.
- b) Frequently the beach is reshaped for the coastal protection work and for creating beautiful scenery.
- c) So often the beach landward is reclaimed for more housing land and walkway.

Most of the hoteliers built their facilities in the narrow space between the road and beach. Land reclamation protected by a small seawall in same area have been constructed by them. The new lands were frequently damaged by cyclones.

4) Land use zone four: Rural Areas "B"

The beach road in this area runs about 75 meters landward from the beach top. The first 25 meter area is covered by flora and architectural facilities including houses that are located within next 50 meters. When a house is built near the shoreline, natural trees are often cut down for grading flat lawn areas. Public spaces, such as for hospitals, sports grounds and schools are often developed in this area.

According to the government agencies, utilities, such as water supply and power distribution mains are embedded under the road shoulder shoreward.

Most of local shops and restaurants are located along the road.

5) Land use zone five: Natural Areas

A typical section of this zone is similar to zone four except for the following:

- a) Wider space between the road and beach
- b) Very little artificial impact within the first 50 meters from the beach

## Chapter 5: Damage by Waves and Surges



## Chapter 5 Damage by Waves and Surges

### 5.1 Cyclones and Damages

#### 5.1.2 Cyclones

The property damage records for Cyclone Sally Jan. 1987 were prepared by the Cook Islands Government. However, the cyclones that affected the island were not only limited to Sally.

The perception study shows the grade of damage caused by each cyclone. According to this data, the worst cyclone in respect to coastal damage was Cyclone Sally which was much more severe when compared to the others. Table 5-1 shows the villagers' feeling about disaster grade of each cyclone.

Table 5-1 Cyclones and Damage Grade

unit : Share of support by interviewees.					
No.	Cyclone	Year	Worst One by Waves (%)	Worst Three by Wave and Wind (%)	Remarks
1.	Peni	1990	4.9	31.5	Second worst
2.	Sini	1990	0	0.6	
3.	Wini	1987	0	2.2	
4.	Sally	1987	88.5	49.7	Worst
5.	Ima	1976	1.6	1.1	
6.	Charlie	1976	0	3.3	
7.	Dolly	1965	4.9	10.5	Third worst
8.	Ofa	-	0	1.1	
			100.0%	100.0%	

Source : Perception Study made by a joint team between MOMEF and the team.

From the standpoint of damage by waves/surges and winds, the worst cyclone was Sally in 1987. The second was Peni in 1990 dominated by winds, and the third was Dolly in 1965. Wave intensity of the top two cyclones was estimated by the study team as follows.

Cyclone	Wave height* (m)	Wave period (sec.)	Direction
Sally	8.1	12.5	N6°W
Sally	7.1	13.1	N21°W
Peni	3.4	7.3	S

Source: Study team

### 5.1.2 Direct Damage on On-land Facilities

The scope of damage survey conducted by MOW covers a wide range of facilities, since most of the island's development, including the provision of public utility mains, is conducted along the beach road. Direct on-land facility damage can be divided into two categories: damage to the public sector and damage to the private sector.

### 5.1.3 Direct Damage along the Shoreline

Waves and littoral currents during the cyclone frequently wash out the deposits along the shorelines. This action makes the beach area narrower. Direct beach damage can be divided into two categories: damage to fine particles such as sand, and damage to coarse particle such as the coral segment and gravel.

a) Damage to fine particles: Beach Erosion

b) Damage to coarse particle: Coastal Erosion

The former may be caused even by small-scale cyclones due to the high sensitivity of fine particles to coastal current forces. While the latter may be caused by large-scale cyclones. In some cases the coarse particles like a coral fragment may be dumped on top of beach banks and form permanent land.

c) Damage on the reclaimed land

This type of damage happens frequently if the seawall foundations for reclamation are not suitable.



## 5.2 Past Direct Damage caused by Cyclones

### 5.2.1 Direct Damages by Sally

This section deals with the direct damage caused by Cyclone Sally. Most of the figures are taken from the report titled "Hurricane Damage Reconstruction Programme for Rarotanga" issued by MOW, 27 January 1987.

Table 5-3 Total Restoration Cost in Damage by Wave: Sally  
unit 10<sup>3</sup> Dollars in 1992 price

Work Items	By Wave
a) Public Sector:	
- Government buildings	1,151.0
- Church buildings	16.0
- Clinic, community halls	25.5
- Water supply system	450.5
- Power supply system	-
- Roads and drains	2,201.5
- Bridges and culverts including stream embankment and foreshore erosion	4,375.0
- Coastal loss*	2,356.9
- Others (20% of above total) 10,576.4 x 0.2 =	2,115.3
Subtotal	12,691.7
b) Private Sector:	
- Residential houses	946.0
- Hotels and motels	18.0
- Shops and stores	38.0
- Others (20% of above total) 1,002.0 x 0.2 =	200.4
Subtotal	1,202.4
Total damage costs	13,894.1

### 5.2.2 Indirect Damages

There may be other damage which can not be directly counted in monetary figures, namely indirect damage.

- a) Damage to beach roads may disrupt vehicular traffic and have an adverse impact on the island economy.
  - b) Damage to the existing airport may disrupt international transport and tourism industries.
  - c) Damage to the port facilities may disrupt not only the importing of daily consumption but also the domestic maritime transport.
  - d) The downing of power supply mains embedded along the beach road may affect industrial activities.
  - e) Shortage of water supply as a result of damage to the distribution main embedded in the beach road may have an effect on the daily lives of villagers.
  - f) Closing of stream mouth may cause inland flooding.
  - g) Erosion of the beach shoulder may affect tree life, and have an adverse effect on the natural environment.
  - h) Large-scale damage in the Avarua area may affect the tourist industry.
  - i) Large-scale property damage may cause insurance rates to rise.
  - j) Investor may be reluctant to develop facilities for their business along the beachline where large-scale damage was experienced.
- Thus, an expected employment opportunity may be lost.

### 5.3 Expectation to Coastal Protection

Total direct damage by cyclone wave in 30 years amounts 130 million Dollars. This cost represents almost 200 % of the national budget at present. The paramount purpose of coastal protection is to protect the lives of people, however reported past life loss is light. Thus, the subject of protection will focus on the mitigation of damage to both property and natural resources.

### 5.3.1 Mitigation of Direct Damage to Coastal On-land Facilities

The most important objective here is to eliminate damage to on-land facilities both public and private. Total on-land facility damage by Sally was 11.1 million dollars, (80 % of the grand total 13.9 million dollars). The share of cost among the public and private sectors is 91 % and 9 % respectively. Among the public on-land facilities, the most damage was done to civil works including bridges, culverts, foreshore protection, and stream embankments. Second was the damage done to the same works including roads and drains. Third was the damage done to the government offices and buildings.

These damage can be summarized as follows:

- a) Roads and their surrounding public facilities
- b) Government offices and buildings

All these facilities are so important that their damage may affect villager's life. The most inflicted damage on private on-land facilities was done to residential houses. Second was the damage done to shops and stores. Damages to hotels, and motels, was reported as being minor.

The main cause of these damages were the rushing of waves landwards followed by the erosion of facility foundations. Coastal protection work should aim at protecting facilities by decreasing wave overtopping the existing beach tops where both public facilities and private facilities are concentrated.

### 5.3.2 Mitigation of Direct Damage along the Shoreline

This covers the following three categories of damage:

- Beach Erosion
- Coastal Erosion
- Failure of Reclaimed Land



Beach erosion by Sally mainly occurred when the high velocity coastal current caused sand deposits to drift offshore. Coastal erosion and the failure of reclaimed land occurred when wave running up washed away the beach slope composition. The total cost of these three disasters by Sally amounted to 2.8 million dollars and shared 20 percent of the total of damage.

Beach erosion damage should be estimated based on the changes in economic values of each beach. In some cases, beach erosion will not cause significant problems if there is no coastal erosion. For tourism industries, however, beach erosion can result in large business losses.

Thus, protection work for coast itself should aim at protection of beach slopes to prevent coastal erosion, and establish countermeasures, when required, for making littoral current moderate and minimizing sand drifting.



Edge Water Hotel being built too close to the beach, urgent sea wall was constructed, Tokorau District



## **Chapter 6: General Policies in the Master Plan**





## **Chapter 6    General Policies in the Master Plan**

### **6.1    Objective of the Master Plan**

The latest Five Year Plan identifies five broad national development policies that include:

- 1) To raise the level of prosperity of the people of the Cook Islands (to stem further migration).
- 2) To attain of a larger measure of economic independence.
- 3) To ensure that economic development proceeds in a manner compatible with social, cultural and natural values.
- 4) The promotion of a more equitable distribution of the benefits derived by development.
- 5) To cooperate closely with Pacific neighbors and other nations in economic affairs and other matters of mutual interest.

These demonstrate a strong desire to construct a country in which the people here enjoy their living in harmony with others by activate economy, generating employment opportunity and industrial development.

Thus the objective of Master Plan is to provide a long-term scheme for the coastal protection and port improvement in Rarotonga Island taking the National Policies and the request by the Government of Cook Islands into consideration.

### **6.2    Master Plan Policies**

This section deals with the general policies in the preparation of Master Plan for the coastal protection and port improvement in Rarotonga Island.

- a) Appropriate Project Scale
- b) Long-term Prospective
- c) Encouragement to the Industries
- d) Flexibility in Land Use
- e) Maintenance of Transport Life Line
- f) Technical Justification
- g) Consideration to Locality
- h) Environmental Consideration
- i) Phasing of Project Components



## **Chapter 7: Master Plan for Coastal Protection**



## **Chapter 7 Master Plan of Coastal Protection**

### **7.1 Purpose of the Protection Work**

Protection work will be provided for coastal on-land facilities and the shoreline where required. The work will target on the mitigation of damage by waves and surges caused by cyclones.

Of the facilities to be protected, the ports should be provided with special care since they are exposed to the open sea and are the most susceptible to cyclone damage. Thus, the port layout must be studied carefully.

#### **7.1.1 General Descriptions**

The coastal protection work should aim mainly at:

- a) Mitigating direct damage to coastal on-land facilities
- b) Mitigating direct damage to the shorelines
- c) Consideration to the combined direct damage brought on by the previous two items

The protection work should be conducted based on priority, the larger damage forecasted the larger the investment for the work contrarily, the less damage the lower the investment. Other than above direct damage, consideration to the following indirect damage should be taken into account.

- a) Damage to the beach road
- b) Damage to the existing airport
- c) Damage to the port facilities
- d) Damage to the power supply system and water supply system
- e) Damage by river mouse closing
- f) Disruption to the natural environment
- g) Other indirect damage

#### **7.1.2 Suggestion by Villagers**

According to the perception study on the cyclone disasters, people here are aware of the major reasons for coastal damage.

Table below shows the causes of coastal disaster which villagers believe.

Order	Causes *	Supporting Rate (%)
(i)	No coastal protection works	31.2
(ii)	Beach eroded naturally	24.0
(iii)	Don't know	15.2
(iv)	Building house close to the beach	12.8
(v)	Digging the beach sand	8.8
(vi)	Just a nature in Rarotonga	8.0
(vii)	Others	0.0
Total		100.0 %

Next table indicates the coastal protection countermeasures proposed by villagers.

Order	Proposed Countermeasures	Supporting Rate (%)
(i)	Planting trees along the beach	25.1
(ii)	Provide protection works	25.1
(iii)	Stop digging up beach sand	20.2
(iv)	Build concrete house	10.0
(v)	House relocation to other site	9.5
(vi)	Provide stormwater drainage	8.7
(vii)	Don't know	1.0
(viii)	Others	0.4
Total		100.0%

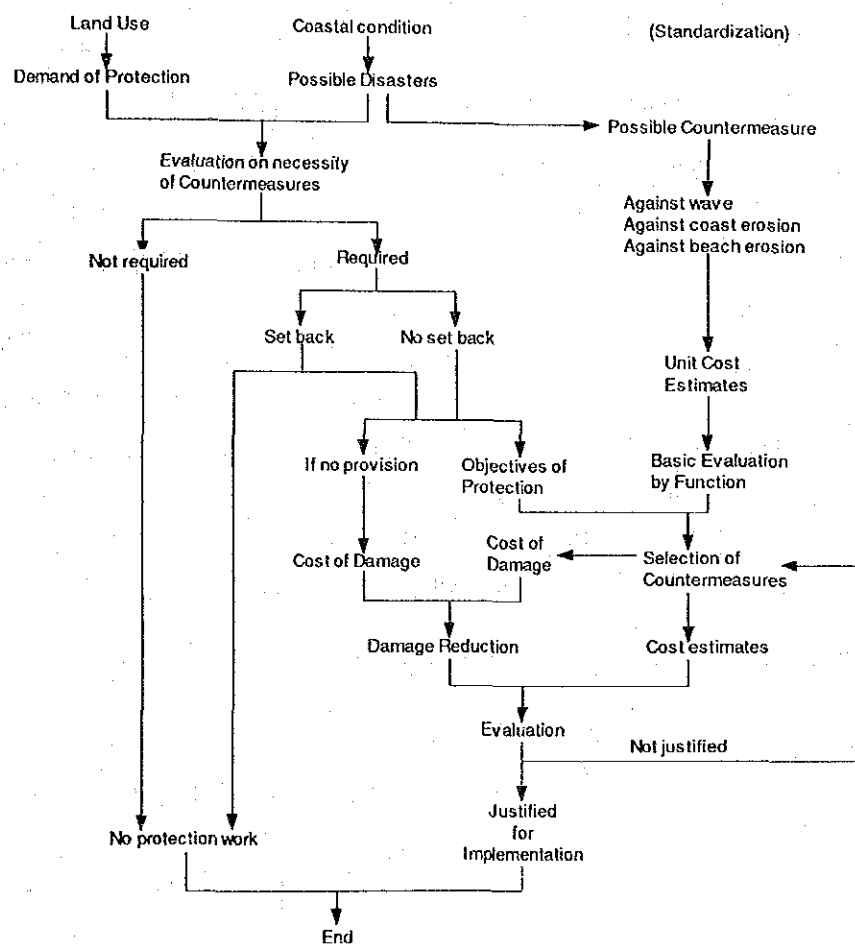
Note: Countermeasures here are for cyclone wave, not for wind forces.

Following can be said when damage causes are superimposed on the countermeasures proposed.

- (i) They strongly desire provision of coastal protection works by the central government.
- (ii) Many villagers want to plant trees along the beach bank.
- (iii) "Digging sand" is not main cause but they want to stop it.
- (iv) They are feeling that they built house too close to the beach, however majority of them want to stay there.

### 7.1.3 Methodology of Master Plan Preparation

#### 1) Basic Method



## 7.2 Possible Type of Protection System

There are two basic coastal protection systems, namely, soft countermeasures and hard countermeasures. The former represents a disaster protection system not requiring construction, while the latter a protection by civil work.

### 1) The Soft Countermeasures

#### a) National Consensus

Without clear information and a future plan, protection work will not be supported by the taxpayers. As discussed in Chapter 6, the preparation of a "Coast File" will provide people with more knowledge about coasts where they live. The "Coastal Disaster Forecast" will provide people with data concerning the possibilities of cyclone disasters. This information will enforce their decision-making concerning investments along the beaches. Disclosure of coastal protection Master Plan will be most important one in order to create the national consensus.

#### b) Enforcement of Regulations

MOW and the Conservation Department among others may be the governmental agencies that will manage coastal area development by the private sectors. If any private coastal development is assumed to be prone to cyclone damage, the responsible agencies should provide advice for modifying the safety plan. If any development is assumed to add to the damage cyclones caused to the surroundings, the agencies should take appropriate action to change such development.

#### c) Share of Responsibility

If villager builds his house in the dangerous coastal area even though he knows this, it is difficult to justify to spend national budget for protection of the house. Discussion of responsibility sharing between the private sector and the government in respect to coastal protection may be necessary.



#### d) Incentive

An incentive provision for developers may be necessary if they take the necessary action to protect the coastal area from the cyclone disasters.

#### 2) The Hard Countermeasures

The countermeasures include both the Micro Concept and Macro Concept. The former takes in the countermeasures that may be performed along the shoreline. The latter takes in the various methods that may be conducted on-land or at the lagoon seaward.

Application of these systems depends upon the existing locality both of land use and possible type of coastal disaster at the site to be protected.