No.

PREPARATORY SURVEY REPORT ON THE PROGRAMME FOR CLIMATE CHANGE IN THE PACIFIC ISLANDS

(Water Resources Management/Meteorological Observation/Disaster Prevention)

Jun 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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LETTER OF TRANSMITTAL

Jun, 2009

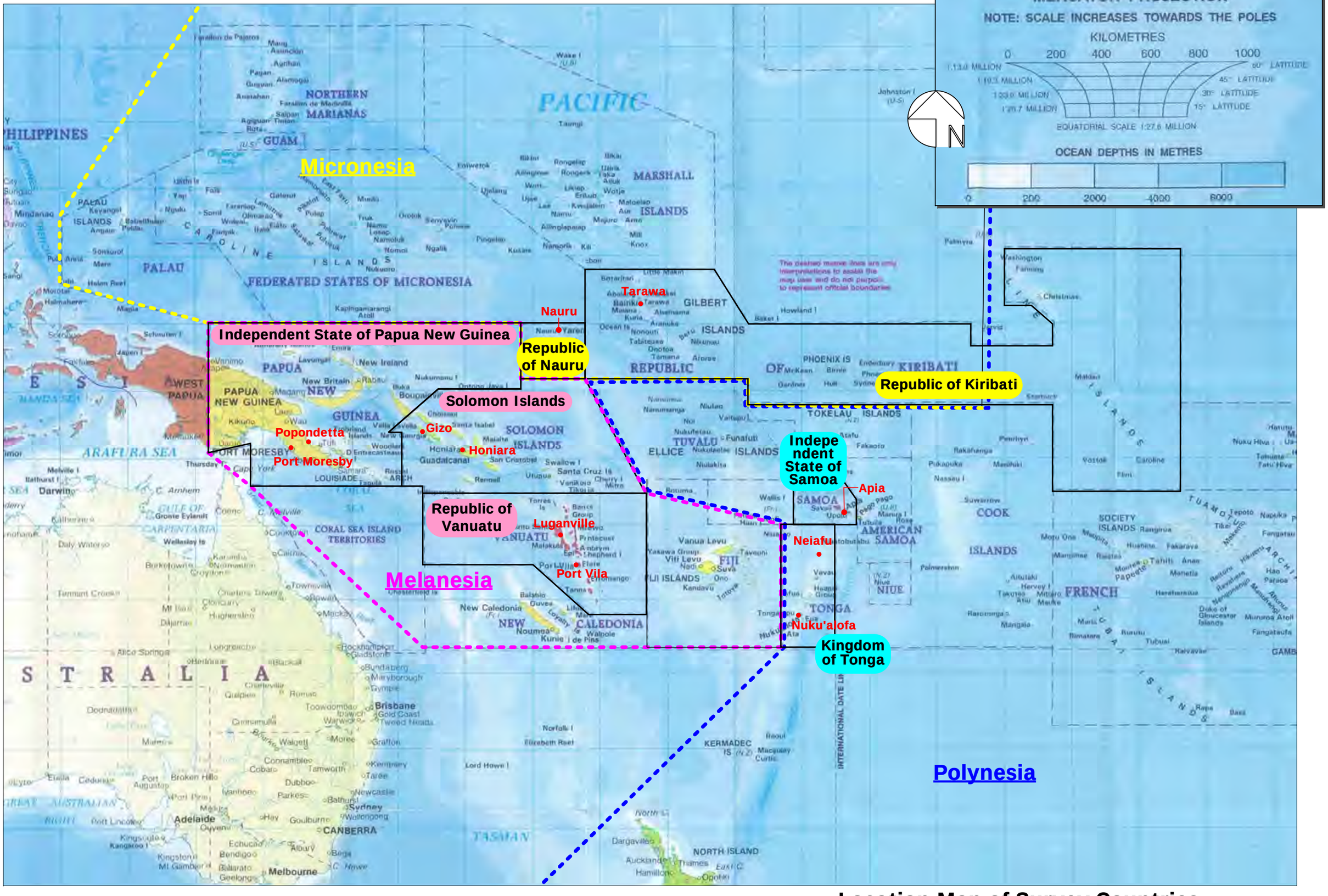
We are pleased to submit to you the Preparatory Survey Report on the Programme for Climate Change in the Pacific Islands (Water Resources Management/Meteorological Observation/Disaster Prevention).

This Study was conducted by Yachiyo Engineering Co., ltd., under contract to JICA, during the period from March 2009 to Jun 2009. The report took into account of the advices and suggestions of your Agency. Also included are comments made by seven target countries (Nauru, Kiribati, Papua New Guinea, Vanuatu, Samoa, Tonga, Solomon Islands).

This report has proposed direction of adaptation and mitigation measures to climate change for seven target countries. We hope this report will contribute to further strengthening of the measures to climate change for the target countries.

Very truly yours,

Masatsugu Komiya
Team Leader,
Preparatory Survey on the Programme for Climate Change in the Pacific Islands
(Water Resources Management/Meteorological Observation/Disaster Prevention)



● : City of Survey's Site

Location Map of Survey Countries

Water Resources Management (1)

Well field in water sources in Matakieua for capital Nuku'alofa, Tonga. Salinity of groundwater from the wells is high (E.C. is more than 1,000uS/cm). People traditionally do not drink supplied water.

Rural water supply facilities by Japanese Glass Root Grant Aid Project (Tefesi village in Tonga). In rural area there are many villages where it is difficult to construct facilities for water supply such as rainfall tank

Main water treatment plant in Capital City Apia (slow filtration plant in ALAOA). Turbidity of water become high by torrential rainfall, and filter is clogged with mad.

Facilities for rural water supply managed by the Government (Luhiluhi village in Samoa). Government is shifting water sources from springs and shallow wells with water quality problems to safety sources of the Government.

Distribution reservoir made of steel (Luganville-Vanuatu). This tank is too old to distribute water in emergency.

Shallow well for water supply source (Luganville-Vanuatu). It is located where the well might be submerged in torrential rainfall.

Water Resources Management (2)

Rainfall tank in Nauru. Many houses have this type of f tanks, but it cannot be utilized in dry season.

Desalinization plan in Nauru. Produced water by the plants is only drinkable water in dry season. They have only 3 water trucks and water delivery is usually delayed.

Hand dug well in Kiribati. Sea water intrusion made salinity of groundwater of this well high, and people cannot drink water.

A well for public water supply in Tarawa of Kiribati. Stalinization of groundwater of this well is advancing and new groundwater development is planned.

A well in Aua Island op Papua New guinea. Water of this well cannot be drunk because of high salinity (provided by NDC).

A well in Kwai Island of Solomon Islands (outer island of Auki). Stalinization is proceeding in this well.

Meteorological Observation and Disaster Prevention (1)

Meteorological Observation

Meteorological observation station in Port Moresby in Papua new guinea. Due to Lack of instruments and old instruments, basic data cannot be obtained.

Metrological observation station in Nauru, Observed data is directly sent to Australia without being used in Nauru.

Communication room of National Emergency Management Office (NEMO) of Tonga. Desk on wireless instruments is in a mess.

Yard of Meteorological observation station in Samoa (provided by Japan) is inundated by high tide in a cyclone

Flood

Damage of road bridge by Boana flood in Pupa new guinea (NDC). Trunk road in local area was interrupted and big damage was given to daily life in rural residents.

Village washed away by flood in February 2009, Guadalcanal province of Solomon Islands. There were many sufferers and victims.

Meteorological Observation and Disaster Prevention (2)

Vaisigano river flowing in Capital Apia city in Samoa. Even center of the city was inundated in flooding in 2001 and 2006.

Flood in is usually occurring and embankment is constructed to prevent overflowing of flooding water at 7-star area of Portville, Capital of Vanuatu.

Coastal erosion

Situation of coastal erosion near Radio station of Kiribati. Part of radio-earth was washed away by erosion.

Coastal road in Auki province of Solomon islands. Trunk road is submerged at high water and traffic is interrupted.

The previous shoreline is seen in left side of this photo. Seawall was newly constructed by support of Canada, but seawall is inundated by overtopping of waves when cyclone.

Coastal erosion is advancing near local truck road near market n Naruruna village in Santo island of Vanuatu.

CONTENTS

List of Table and Figure

Abbreviation

[Government]

ADB	Asian Development Bank
AusAID	The Australia Agency for International Development
CIM	Coastal Infrastructure Management
DDC	District Disaster Committee
EU	European Union
GEF	Global Environment Facility
IDA	International Development Association
MNRE	Ministry of Natural Resources and Environment
NACCC	National Committee of Climate Change
NBC	National Broadcasting Station
NDC	National Disaster Center
NDMO	National Disaster Management Office
NEMO	National Emergency Management Office
PDC	Provincial Disaster Committee
PWD	Ministry of Public Works
PUB	Public Utilities Board
SIWA	Solomon Islands Water Authority
SOPAC	South Pacific Applied Geoscience Commission
SPREP	South Pacific Regional Environmental Programme
TWB	Tonga Water Board
UNDP	United Nations Development Programme
WMO	World Meteorological Organization
WB	World Bank

[General]

ARM	Atmospheric Radiation Measurement
CBA	Community Base Adaptation
CCSDP	Community Center Sustainability Development Programme
CRP	Climate Risk Profile for Samoa
DG	Director General
GDP	Gross Domestic Product
GIS	Geographic Information System
HYCOS	Hydrological Cycle Observation System
INC	Initial National Communication
IWRM	Integrated Water Resource Management
KAP	Kiribati Adaptation Project
LDC	Least Developed Country

MDGs	Millennium Development Goals
MOU	Minute of Understanding
NAP	National Action Plan
NAPA	National Adaptation Programme of Action
NC	National Communication
NGO	Nongovernmental Organization
PNG	Independent State of Papua New Guinea
SNC	Second National Communication
UNFCC	United Nations Framework Convention on Climate Change
WSP	Water Safety Plan

Summary

1. Background of the Study

Having very limited land area and low altitude, the Pacific island nations are extremely prone to the effects of climate change and are in urgent need of strategic countermeasures. In particular, coastal erosion caused by rising sea levels, flooding and destruction of property caused by cyclones, and natural disasters such as droughts and so on are increasingly serious threats, and it is necessary to mitigate the damage from such problems as well as enhance the capacity to respond to natural disasters.

To support measures for addressing climate change in the Pacific island nations and the like, the Government of Japan announced the Cool Earth Partnership as a fund mechanism. Application of the Mechanism entails twofold support to developing countries that have undergone policy discussions: either support centering on assistance for access to adaptation measures and access to clean energies based on grant aid and technical aid, etc., or yen loans for climate change countermeasures focusing on mitigation measures. In view of this policy by the Government of Japan, and as its basic policy of support for climate change countermeasures in developing countries, JICA aims to strengthen efforts for cooperation geared to raising the capacity of Pacific island nations to respond to climate change.

Against this background, with a view to bolstering Japan's support for climate change countermeasures in the Pacific region, JICA dispatched the Study Team from March 21 through April 19, 2009 in order to conduct surveys and grasp needs in the fields of water resources management, meteorological observation and disaster prevention, to examine adaptability to Pacific island nations, and to examine the direction of adaptation measures and mitigation measures in each country and wide areas covering a number of countries.

2. Objectives of the Study

The objectives of the Study are as follows:

- To select countries that require countermeasures in the fields of water resources, meteorological observation and disaster prevention and to gauge needs for strengthening support for climate change countermeasures; and
- To formulate climate change adaptation measures and mitigation measures concerning the fields of water resources, meteorological observation and disaster prevention in the target countries.

The Study targets the following seven countries: Republic of Nauru (hereinafter Nauru), Republic of Kiribati(hereinafter Kiribati), Independent State of Papua New Guinea (hereinafter PNG), Independent State of Samoa (hereinafter Samoa), Kingdom of Tonga (hereinafter Tonga), Solomon Islands (herein after Solomon Islands)

3. Study Findings

3.1 Current Vulnerability

The seven targeted countries are composed of variously sized islands. The islands of Samoa, Vanuatu, Tonga, the Solomon Islands and PNG are large enough to have river systems, whereas Kiribati and Nauru are very small islands having no rivers. The vulnerability of these countries in terms of water resources management, meteorological observation and disaster prevention reflect these geographical and natural conditions.

Meanwhile, as a result of economic development, population has increased in the low-lying coastal areas of these countries in recent years, showing various kinds of effect due to population pressure. In spite of the dangers of natural disasters in such areas, population has continued to rise due to the urbanization of coastal areas and problem of landless migrants. As a result, this has triggered indiscriminate development and environmental degradation of the coastal areas, thereby aggravating their vulnerability. It is necessary to look at natural conditions as well as socioeconomic conditions when examining the background to climate change.

(1) Water Resources Management

The seven target countries obtain water from rainwater, groundwater and river water, although river water is not available on the smaller islands because of no river. Nauru and Kiribati also conduct the desalinization of seawater as measures to water shortage. All the countries are confronted with the problem of well water Stalinization in coastal areas, resulting from rising sea level that is an outcome of climate change. Moreover, the prolonging of droughts, again as a result of climate change, is causing the serious depletion of river flows and groundwater reserves. This depletion of water resources during droughts is leading to critical water shortages. Moreover, since the target countries use rainwater for water supply, this is another area that suffers due to extended droughts. Meanwhile, as opposed to the reduction in rainfall, growing frequency of torrential rain also caused by climate change is causing the inundation and damage of water supply facilities, and the resulting breakdown of water supply facilities and infiltration by turbid water are causing interruptions to water supply.

(2) Meteorological Observation and Disaster Prevention

The seven target countries are scattered over a wide ocean area, however, their meteorological observation networks don't cover entire national boundaries and there are shortages of observation equipment. Moreover, since telecommunications networks are not established between main and remote islands and meteorological forecasting technology is inadequate, the meteorological observation setups in each country are lacking in terms of both quality and quantity.

Concerning disaster prevention, all seven countries are experiencing inundation of coastal areas and damage to roads and houses as a result of the rising sea level. Also, coastal erosion is leading to damage of important infrastructure facilities such as coastal roads, causeways, schools and hospitals, etc. The cutting of mangroves and destruction of coral reefs are also contributing to this coastal devastation. Coastal disasters are a common problem for all seven countries.

Meanwhile, due to increasingly frequent torrential rainfall brought about by climate change, flooding and sediment disasters are occurring in PNG, Vanuatu, Samoa and the Solomon Islands, and these are imparting serious damage to houses, roads, bridges and other infrastructure. Flooding and sediment disasters are conspicuous on the larger islands of PNG, Samoa and the Solomon Islands.

(3) Future Impacts

According to the 4th Assessment Report of the IPCC, there is no doubt that global warming will progress further from now on. In other words, it is projected that the phenomena of rising sea level, prolonging of droughts, and increasing frequency of torrential rain, etc. will become more acute in future. As a result, it is forecast that salinization of groundwater and water shortages, coastal submergence and erosion will become more pronounced, and that flooding and sediment disasters will become more widespread and frequent.

Tourism is an important industry for the seven targeted countries; for example, the tourism industry accounts for 40% of GDP in Vanuatu and 25% in Samoa. However, it is forecast that the impacts of climate change will steadily affect the tourism industry through impeding basic water and disaster management infrastructure and harming tourism resources such as coral reefs (blanching), etc.

3.2 Government Measures

Kiribati, Vanuatu, Samoa and the Solomon Islands, have already compiled National Adaptation Programmes of Action (NAPAs[1]) in response to climate change, and in these they have selected the adaptation measures that urgently need to be implemented. The priority fields and order of adaptation measures differ slightly according to conditions in each country, however, measures concerning the securing of water resources, coastal conservation and other disaster prevention measures, and strengthening of meteorological observation are commonly listed by each country, and these countries are seeking support from donors for the implementation of these measures.

On the other hand, Nauru, PNG and Tonga haven't compiled a NAPA yet, although all three of these countries are vigorously addressing climate change countermeasures. Nauru has established the National Committee on Climate Change to examine the matter; PNG has established the Climate

1 Tonga does not formulate NAPA because Tonga is not Latest Developed Country (LDC).

Change and Environmental Maintenance Department and has adopted a government-wide approach to climate change; and Tonga has established the Climate Change Project Department and aims to incorporate climate change countermeasures into its legal system.

3.3 Cooperation Needs

The cooperation needs in the fields of water resources management, meteorological observation and disaster prevention in the seven target countries show a lot of contents that are common to all the countries due to the similarity of natural and socioeconomic conditions in each.

(1) Water Resources Management

The target countries contain a lot of small islands, and since river water is scarce on such islands, islanders frequently rely on groundwater and rainwater for their water needs. Accordingly, groundwater salinization countermeasures and water shortage countermeasures were confirmed as common needs in each country. Since salinized well water cannot be used as potable water, rainwater becomes a precious source of water for drinking. However, because rainwater cannot be used during dry seasons, water shortages at such times become critical, and this problem is exasperated even more in provincial areas. Meanwhile, Nauru and Kiribati, where drought is more frequently occur, have high need for works to expand water supply in their capital cities.

(2) Meteorological Observation and Disaster Prevention

Concerning meteorological observation, installation of meteorological observation stations, observation instruments and communications networks and improvement of meteorological observation capacity and forecasting capacity were confirmed as common needs in the seven targeted countries.

Regarding disaster prevention, measures to counter submergence of coastal areas and coastal erosion countermeasures were confirmed as common needs in all countries. On small islands with altitude almost at sea level, coastal houses and important infrastructure facilities are threatened by erosion and are in urgent need of countermeasures. Meanwhile, on larger islands that possess wide river systems, there are high needs for flood countermeasures and sediment disaster countermeasures. In PNG, which possesses a large main island, and the larger size Solomon Islands and Samoa, flooding and sediment disasters have become serious problems. The countries also have common needs regarding disaster early warning systems, disaster prevention enlightenment activities and installation of disaster radio communication systems between islands. In addition, there are also high needs for preparation of integrated hazard maps, disaster countermeasures /accumulation of data on coastal erosion that utilize remote sensing, and training of disaster countermeasure engineers.

3.4 Donor Support

Donors concerned with climate change in the Pacific are broadly divided into local agencies, international agencies and bilateral donors. Concerning activities by local agencies, the Secretariat of the Pacific Islands Applied Geo-Science Commission (SOPAC), Secretariat of Pacific Regional Environmental Programme (SPREP) and University of South Pacific (USP), etc. implement wide area projects in the fields of water resources management and disaster prevention for member nations. Funds for such activities are provided by international agencies and bilateral donors. International agencies active in the Pacific include the United Nations Development Plan (UNDP), World Bank and Asian Development Plan (ADB). The UNDP conducts support for the compilation of NAPA, while the World Bank provides support for coastal infrastructure management and cyclone countermeasures, etc. The ADB intends to strengthen its support for adaptation measures addressing climate change. In the area of bilateral assistance, AusAID is the largest donor in the field of climate change in the Pacific and it places emphasis on meteorological observation and meteorological data building activities, etc. in its support. The EU and NZAID primarily implement wide area support projects through providing funds, etc. to SOPAC and SPREP.

Concerning the needs that were ascertained in the target seven countries in the Study and the contents of support that were proposed as a result of the Study, there is no schedule for the implementation of support by overseas donors at the present time. Before implementing individual assistance projects in future, it will be necessary to reconfirm trends among overseas donors.

4. Direction of Cooperation Geared to Mitigation of Vulnerability

Tables 1 and 2 summarize the country-separate direction of cooperation for mitigation of vulnerability in the seven targeted countries, while Table 3 shows the direction of wide area support. As may be gathered from the tables, the proposed support covers a wide variety of directions and can be summarized into the following three points:

① Development of alternative water sources and integrated water resources management
Mitigate water shortages through securing new water sources and normalizing use of existing water sources, in order to address salinization of water and water supply shortages caused by climate change.

② Meteorological observation capacity building relating to climate change
Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change.

③ Climate change risk management
Manage risks linked to climate change in order to mitigate the impacts of climate change.

As is indicated in Tables 1 and 2, there are many common countermeasures, and this is due to the fact that the seven targeted countries share much in common in terms of natural conditions and socioeconomic conditions relating to water resources management, meteorological observation and disaster prevention. Moreover, in countries that have compiled NAPAs, the contents of these programmes have been reflected in the countermeasures.

Technology transfer measures and countermeasures based on dissemination and enlightenment should be implemented as wide area activities. The same thing applies to support for meteorological observation. Since the impacts of climate change are manifesting gradually but will appear conspicuously in 50 and 100 years time, when confirming impacts and compiling plans to address them, it will be essential to build up long-term data, and work on a project for preparing a system to collect data should be started now.

Meanwhile, since projects concerning water resources infrastructure and disaster prevention infrastructure construction are greatly affected by the localized topographical and geological conditions of construction sites, rather than wide area support, it is desirable to implement them as bilateral support.

Table 1 Country-Separate Direction of Support Geared to Mitigation of Vulnerability concerning Water Resources Management, Meteorological Observation and Disaster Prevention (1)

Direction of support		Implementation period	Example of Measures	Target Country						
				Nauru	Kiribati	PNG	Vanuatu	Samoa	Tonga	Solomon Islands
Development of alternative water sources and integrated water resources management	Mitigate water shortages through securing new water sources and normalizing use of existing water sources, in order to address salinization of water and water supply shortages caused by climate change.	Short term	Improvement of water supply in capital city		○					
		Short term	Nationwide emergency water shortage countermeasures				○	○	○	
		Short term	Conservation of the freshwater lens through promoting rainwater recharging based on use of community facilities	○						
		Short term	Underground storage of rainwater	○						
		Short term	Community development of ponds			○				
		Short term	Salinization countermeasures capacity building and master plan preparation			○				
		Short term	Groundwater improvement							○
		Short term	Water utilization improvement							○
		Medium to long term	Water supply improvement on remote islands		○					
		Medium to long term	Nationwide water supply and demand improvement				○	○	○	
		Medium to long term	Sanitation management and enlightenment activities in community water management		○					
		Medium to long term	Human resources development and capacity building for water resources management		○					
		Medium to long term	Water storage projects linked to micro hydropower			○				
		Medium to long term	Monitoring of groundwater reserves and quality			○			○	
		Medium to long term	Water leakage and conservation measures						○	
Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change.	Short term	Training of meteorological and disaster forecasters, improvement of data analysis and forecasting technology	○	○	○	○	○	○	○
		Short term	Construction of observation networks		○	○		○		

Note 1: Short term refers to support that should be implemented in 2~3 years. Medium to long term refers to support that should be implemented over around 5 years.

Table 2 Country-Separate Direction of Support Geared to Mitigation of Vulnerability concerning Water Resources Management, Meteorological Observation and Disaster Prevention (2)

Direction of support		Implementation period	Example of Measures	Target Country						
				Nauru	Kiribati	PNG	Vanuatu	Samoa	Tonga	Solomon Islands
Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change.	Short term	Compilation of infrastructure design criteria for disaster prevention		○	○	○	○	○	○
		Short term	Compilation of disaster (drought) countermeasures criteria	○						
		Short term	Capacity building of disaster countermeasure implementing agencies		○	○	○	○	○	○
		Short term	Installation of disaster and disaster prevention radio communications network		○					
		Short term	Urban coastal erosion countermeasures		○		○		○	
		Short term	Integrated hazard map preparation and coastal management capacity building		○	○	○	○	○	○
		Short term	Installation of early warning equipments		○	○	○	○	○	○
		Short term	Dissemination and enlightenment activities	○	○	○	○	○	○	○
		Short term	Disaster broadcasting capacity building		○	○	○	○	○	○
		Short term	Installation of equipment for adapting to disaster broadcasting		○	○				
		Short term	Construction of multipurpose cyclone shelters						○	
		Short term	Construction of urban drainage facilities				○		○	
		Short term	Port construction projects	○						
		Medium to long term	Information collection on disaster countermeasures / coastal erosion		○	○	○	○	○	○
		Medium to long term	Remote island coastal erosion countermeasures technology capacity building		○		○			
		Medium to long term	(City) River flood countermeasures				○	○		
		Medium to long term	Improvement of disaster assessment work capacity					○		
		Medium to long term	Community infrastructure construction projects					○		
		Medium to long term	Construction of drainage facilities in provincial cities				○			
		Medium to long term	High tide countermeasures						○	
		Medium to long term	Bridge and national highway disaster prevention measures			○	○	○	○	○

Note 1: Short term refers to support that should be implemented in 2~3 years. Medium to long term refers to support that should be implemented over around 5 years.

Table 3 Wide Area Direction of Support Geared to Mitigation of Vulnerability concerning Water Resources Management, Meteorological Observation and Disaster Prevention

Direction of support		Implementation period	Example of Measures	Target Country							
				Nauru	Kiribati	PNG	Vanuatu	Samoa	Tonga	Solomon Islands	
Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change.	Short term	Training of meteorological and disaster forecasters, improvement of data analysis and forecasting technology	○	○	○	○	○	○	○	
		Short term	Establishment of a meteorological observation network and sharing of observation data	○	○	○	○	○	○	○	
Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change.	Short term	Compilation of infrastructure design criteria for disaster prevention	△	○	△		○		○	
		Short term	Integrated hazard map preparation and coastal management capacity building			○	○	○	○	○	
		Short term	Dissemination and enlightenment activities				○		○	○	Fiji
				○	○	△		○			Tuvalu
		Short term	Disaster broadcasting capacity building		○	○			○	○	Tuvalu
		Medium to long term	Information collection on disaster countermeasures / coastal erosion	○	○	○	○	○	○	○	
		Medium to long term	Opening of coastal engineering basic course	○	○	○	○	○	○	○	○

Project finding was completed

Note 1: Short term refers to support that should be implemented in 2~3 years. Medium to long term refers to support that should be implemented over around 5 years.

CHAPTER 1 Outline of the Study

1-1 Background of the Study

Having very limited land area and low altitude, the Pacific island nations are extremely prone to the effects of climate change and are in urgent need of strategic countermeasures. In particular, natural disasters such as coastal erosion caused by rising sea levels, flooding and destruction of property caused by cyclones, and droughts are increasingly serious threats. Therefore it is necessary to mitigate the damage from such problems as well as enhance the capacity to respond to natural disasters.

Support for measures to adapt to climate change in the Pacific island nations and the like started with the announcement of the Cool Earth Partnership – a new fund mechanism for climate change worth US$10 billion (1.25 trillion yen) in total – by the then Japanese Prime Minister Fukuda at the Davos summit held in Switzerland in January 2008. Application of the Mechanism entails twofold support to developing countries that have undergone policy discussions: either support centering on assistance for access to adaptation measures and access to clean energies based on grant aid and technical aid, etc. worth 500 billion yen over five years, or yen loans for climate change countermeasures based on mitigation measures also worth 500 billion yen over five years. In the Pacific region, Palau, Micronesia, the Marshall Islands, Nauru, Kiribati, Papua New Guinea, Vanuatu, Tuvalu, Samoa, Tonga, Niue, and the Cook Islands have already joined the Cool Earth Partnership, and of these Kiribati, Vanuatu, Tuvalu, Samoa and the Solomon Islands have already prepared National Adaptation Programmes of Action (NAPA), which are integrated strategy papers outlining adaptation measures.

In view of this policy by the Government of Japan, and as its basic policy of support for climate change countermeasures in developing countries, JICA aims to strengthen efforts for cooperation geared to raising the capacity of Pacific island nations to respond to climate change. Against this background, with a view to bolstering Japan's support for climate change countermeasures in the Pacific region, JICA dispatched the Study Team in order to conduct surveys and grasp needs in the fields of water resources, meteorological observation and disaster prevention, to examine adaptation measures in Pacific island nations, and to examine the direction of adaptation measures or mitigation measures in each country and also wide areas covering a number of countries.

1-2 Objectives of the Study

The objectives of the Study are as follows:

- To select countries that require countermeasures in the fields of water resources, meteorological observation and disaster prevention and to gauge needs for strengthening support for climate change countermeasures; and
- To formulate climate change adaptation measures and mitigation measures concerning the fields of water resources, weather observation and disaster prevention in the target countries.

Target countries of the Study: Republic of Nauru, Republic of Kiribati, Independent State of Papua New Guinea, Independent State of Samoa, Kingdom of Tonga, Solomon Islands

1-3 Study Schedule and Study Team Members

Overall Study period: March 21, 2009 (Saturday) ~ April 19, 2009 (Sunday)

Table 1-3.1 Study Schedule

Date	A Team		B Team	
	Time	Itinerary	Time	Itinerary
March 21 (Sat)	18:30	Depart Narita	21:05	Depart Narita
March 22 (Sun)	12:35	Arrive in Auckland	04:30	Arrive in Port Moresby, PNG
March 23 (Mon)	07:30 10:30 12:00 14:00 15:00 17:00	Depart Auckland Arrive in Nuku'alofa, Tonga Courtesy call and discussions at JICA Tonga office Courtesy call and discussions at the Ministry of Finance and Planning Courtesy call and discussions at the Ministry of Land, Survey and Natural Resources and Environment Courtesy call and discussions at Tonga Meteorological Service	09:00 11:00 13:30 14:30 15:10 15:40	 Courtesy call to JICA Papua New Guinea Office Courtesy call to Japanese Embassy in Papua New Guinea Courtesy call and discussions at the Ministry of National Planning Courtesy call and discussions at the Office of Climate Change and Environmental Sustainability Courtesy call and discussions at PNG Power Ltd Courtesy call and discussions at the Department of Prime Minister & National Executive Council
March 24 (Tue)	08:30 10:00 11:00 14:00 14:00 16:00	Visit to the Department of Statistics Courtesy call and discussions at the Ministry of Land, Survey and Natural Resources and Environment Courtesy call and discussions at AusAID Courtesy call and discussions at the Tonga Water Boand Courtesy call and discussions at the National Emergency Management Office Courtesy call and discussions at NZAID	09:00 10:25 13:10 14:40 15:50 17:00	Courtesy call and discussions at the Ministry of Environmental & Conservation Courtesy call and discussions at the National Statistics Office Courtesy call and discussions at the National Research Institute Courtesy call and discussions at the National Broadcasting Corporation Meeting with the Office of Climate Change and Environmental Sustainability and National Disaster Center Study report and talks with the JICA PNG Office
March 25 (Wed)	 08:00 08:45 09:00 10:00 10:00	<Survey of Vavau> Depart Nuku'alofa Arrive in Neiafu Courtesy call and discussions at Vavau Islands Government Office Field survey <Upolu> Field survey of the Tonga Water Boand.	09:00 11:15 14:00 15:00 16:30	Courtesy call and discussions at the National Disaster Center Courtesy call and discussions at the Eda Ranu (while a separate group collected data at the Ministry of Environmental & Conservation) Data collection at the National Statistics Office and request for data provision at Eda Ranu Courtesy call and discussions at the National Weather Service Tour of facilities at the National Weather Service
March 26 (Thu)	 09:00 16:00 16:45 09:30 10:30 14:00	<Survey of Vavau> Field survey Depart Neiafu Arrive in Nuku'alofa <Upolu> Courtesy call and discussions at the Ministry of Tourism Courtesy call and discussions at the Ministry of Works Courtesy call and discussions at Civil Society Forum in Tonga	08:40 10:30 11:40 13:00 14:30 16:30	Courtesy call and discussions at the EU Office Information collection at the Climate Change and Environmental Maintenance Department Information collection at the National Disaster Center Courtesy call and discussions at the Department of Land & Physical Planning (while a separate group collected data at the Ministry of Environmental and Conservation) Data collection at the National Statistics Office Study report and talks with the JICA Office
March 27 (Fri)	10:00 12:00 15:30	Courtesy call and discussions at the Prime Minister's Office Courtesy call and discussions at the Ministry of Foreign Affairs Discussions at the JICA Tonga Office	09:00 10:30 11:50 12:45 14:00 15:30 16:00	 Data collection at the National Weather Service (while a separate group collected data at the PNG Power Ltd) Courtesy call and discussions at AusAID Data collection at the National Weather Service Courtesy call and discussions at PNG Water Board Report of Study results at the Japanese Embassy in PNG Courtesy call and discussions at the World Bank (while a separate group collected data at the Ministry of Environmental Conservation) Report of Study results at the JICA PNG Office
March 28 (Sat)	17:00	Depart Nuku'alofa	10:00	Tour of broadcasting facilities and discussions at the

Date	A Team		B Team			
	Time	Itinerary	Time	Itinerary		
	17:35 (01:45) 04:35 13:00	Arrive in Nadi, Fiji Depart Nadi Arrive in Apia, Samoa Field survey	13:00	National Broadcasting Corporation Preparation of the field survey report		
March 29 (Sun)	09:00	Field survey	12:00 15:00	Depart Port Moresby, PNG Arrive in Honiara, Solomon Islands		
March 30 (Mon)	09:00 10:00 11:00 14:00 15:30	Courtesy call and discussions at the JICA Samoa Office Courtesy call and discussions at the Ministry of Natural Resources and Environment Courtesy call and discussions at the Samoa Tourism Authority. Courtesy call and discussions at the South Pacific Regional Environmental Planning (SPREP) Office. Courtesy call and discussions at the Samoa Quality Broadcasting Department	09:00 10:50 13:50 16:30	Courtesy call and discussions at the Ministry of Lands, Housing and Surveying Courtesy call and discussions at the JICA Solomon Islands Office Courtesy call and discussions at the National Disaster Management Office Courtesy call and discussions at the Solomon Islands Broadcasting Corporation		
March 31 (Tue)	09:30 10:30 13:00 15:30	Courtesy call and discussions at the Land Management Division Courtesy call and discussions at the Meteorological Division Courtesy call and discussions at the UNDP Samoa Office Courtesy call and discussions at SPREP.	10:00 14:30 17:15	Courtesy call and discussions at the Ministry of Development Planning Aid Coordination Courtesy call and discussions at the Solomon Islands Water Authority (split into two groups) Depart Honiara Arrive in Menen, Nauru		
April 1 (Wed)	09:00 14:00	Field survey of the Samoa Water Authority Courtesy call and discussions at the Samoa Water Authority	10:00 11:15 12:15 14:20 15:30 16:10	Courtesy call and discussions at the Ministry of Commerce, Industry & Environment Tour of desalination facilities at Nauru Utilities Authority Courtesy call and discussions at the Office of President Courtesy call and discussions at the Nauru Rehabilitation Corporation Courtesy call and discussions at the Department of Health Courtesy call and discussions at the Atmospheric Radiation Measurement (split into two groups) Courtesy call and discussions at the Office of President and Government Information Office Courtesy call and discussions at the Nauru Police (split into two groups)		
April 2 (Thu)	09:00 14:00	JICA discussions Depart Apia	10:35 11:20 12:40 14:30 15:00 17:00	Courtesy call and discussions at the Department of Transport Courtesy call and discussions at the Nauru Media Bureau (while a separate group collected data at the Ministry of land Surveying) Courtesy call and discussions at Department of Planning and Policy Division Data collection at the Atmospheric Radiation Observatory Tour of a mineral phosphate quarry Tour of the agricultural test site of the Taiwan Technical Mission in Nauru (while a separate group collected data at the Ministry of Trade, Industry and Environment)		
April 3 (Fri)	18:10	Arrive in Auckland	09:45 10:30 14:00 15:00 16:00	Depart Menen Arrive in Honiara, Solomon Islands Courtesy call and discussions at the Ministry of Environment Conservation and Meteorology Discussions at the National Disaster Management Office Courtesy call and discussions at the Ministry of Infrastructure Development Courtesy call and discussions at the Japanese Embassy in the Solomon Islands (split into two groups)		
April 4 (Sat)	09:30 10:40	Depart Auckland Arrive in Port Vila, Vanuatu	07:00 07:30 09:30 12:00 14:30	Depart Honiara Arrive in Auki Depart Auki Arrive in Mitre Survey of Kwai and Ngongosila Island	Depart Honiara Arrive in Auki Depart Auki Arrive in Mitre Depart Auki Arrive in Mitre	Depart Honiara Arrive in Auki Depart Auki Arrive in Mitre Survey of Kwai and Ngongosila Island

Date	A Team		B Team			
	Time	Itinerary	Time	Itinerary		
			15:00	Depart Mitre Arrive in Auki	Survey of Kwai and Ngongosila Island Depart Mitre Arrive in Auki	Depart Mitre Arrive in Auki
April 5 (Sun)	13:00	Field survey	08:00 09:00 15:30	Depart Auki Survey between Dara and Mauu Arrive in Auki	Depart Auki Survey between Dara and Mauu Arrive in Auki	Depart Auki Survey between Dara and Mauu Arrive in Auki
April 6 (Mon)	08:30 10:00 11:00 14:00 15:40	Courtesy call and discussions at the JICA Vanuatu Office Courtesy call and discussions at the Department of Foreign Affairs Discussions at the Statistics Office Courtesy call and discussions at the Water Resources Management Department of Courtesy call and discussions at the Prime Minister's Office	09:00 09:30 11:00	Depart Auki Arrive in Honiara Data collection at the National Disaster Management Office	Depart Auki Arrive in Honiara Data collection at the National Disaster Management Office	Depart Auki Arrive in Honiara Data collection at the National Disaster Management Office
			11:30 14:00 16:00	Data collection at the Ministry of Environment Conservation and Meteorology Courtesy call and discussions at the Ministry of Natural Resources, Department of Mines and Energy (while a separate group collected data at the Statistics Office) Data collection at the Ministry of Health and Medical Services		
April 7 (Tue)	09:30 10:30 14:00 15:00	Courtesy call and discussions at National Disaster Management Office Courtesy call and discussions at the Department of Meteorology. Courtesy call and discussions at the NZAID Vanuatu Office Courtesy call and discussions at the Ministry of Lands, Energy, Environment, Mining and Water Resources	08:00 13:10 18:30	Report of Study results at the Japanese Embassy in the Solomon Islands and JICA Solomon Islands Office Depart Honiara Arrive in Nadi, Fiji		
April 8 (Wed)	08:30 10:00	Courtesy call and discussions at the Environment Unit Field survey		Data analysis and preparation of the field survey report		
April 9 (Thu)	07:00 08:00 10:00 11:00 13:00	Depart Port Vila Arrive in Luganville Courtesy call and discussions at Luganville Muhici pality Courtesy call and discussions at Samma Provincial Government Field survey (Luganville water supply facilities, etc.)	07:30 10:30 13:50 15:50 16:30	Depart Nadi Arrive in Tarawa, Kiribati Courtesy call and discussions at the Ministry of Environment, Land and Agricultural Development Data collection at the Statistics Office Observation of Bairiki Port		
April 10 (Fri)	09:00 12:30 13:30	Field survey Depart Luganville Arrive in Port Vila	11:00 13:30	Tarawa Island, Bairiki ~ Nippon Causeway survey Survey of Tarawa Island, Betio		
April 11 (Sat)	—	Preparation of the field survey report	11:00 13:30	Survey of Tarawa Island, Bikenibeu coast Survey of Tarawa Island, Tanaea coast		
April 12 (Sun)	—	Preparation of the field survey report	—	Preparation of the field survey report		
April 13 (Mon)	—	Preparation of the field survey report	—	Preparation of the field survey report		
April 14 (Tue)	10:00 11:00 16:00 19:00 22:00	Discussions at the JICA Vanuatu Office Courtesy call and discussions at AusAID Depart Port Vila Arrive in Nadi, Fiji	08:30 10:00 13:30 15:10 16:30	Courtesy call and discussions at the Meteorological Service Courtesy call and discussions at the KAP Office Courtesy call and discussions at the Ministry of Public Works and Utilities, Water Engineering Division Discussions at the Ministry of Public Works and Utilities, Civil Engineering Division Courtesy call and discussions at the Broadcasting and Publications Authority		
April 15 (Wed)	10:00 14:00	Courtesy call, discussions and observation at the University of the South Pacific (USP) Division of Marine Studies.	10:00 11:30 13:50	Courtesy call and discussions at the Ministry of Communications Transport and Tourism Development Courtesy call and discussions at the Ministry of Public Works and Utilities		

Date	A Team		B Team	
	Time	Itinerary	Time	Itinerary
		Courtesy call, discussions and observation at the University of the South Pacific (USP) Pacific Centre for Environmental & Sustainable Development		Courtesy call and discussions at the Office of the President
April 16 (Thu)	10:00 15:00	Courtesy call and discussions at the Pacific Islands Appied Geosciences Commission (SOPAC) Courtesy call and discussions at AusAID	11:30 14:30 18:00	Depart Tarawa Arrive in Nadi, Fiji Arrive in Suva (join with Team A)
April 17 (Fri)	10:30 14:30 15:30 19:00	Courtesy call and discussions at NZAid Courtesy call and report of Study results at the Japanese Embassy in Fiji and JICA Fiji Office Depart Suva Arrive in Nadi		
April 18 (Sat)	08:15 10:30	Depart Nadi, Fiji Arrive in Brisbane, Australia		
April 19 (Sun)	08:15 17:05	Depart Brisbane, Australia Arrive in Narita		

Table 1-3.2 Study Team Members

Responsible Field	Name	Team	Organization	Term of Dispatch
Team Leader	Masatsugu Komiya	A	Yachiyo Engineering Co., Ltd.	March 21 ~ April 14
Vice Team Leader / Water Resources Management	Hiroshi Nakamura	B	〃	March 21 ~ April 19
Disaster Prevention / Meteorology	Tsutomu Kameyama	A	〃	March 21 ~ April 19
Water Supply	Tsuyoshi Onozato	A	〃	March 21 ~ April 19
Coastal Conservation	Hiroshi Hashimoto	B	〃	March 30 ~ April 19
Administration and Human Resources Development	Naoaki Nanbu	B	〃	March 21 ~ April 19
Environmental and Social Impact Analysis	Keiji Ishibashi	B	〃	March 21 ~ April 19

1-4 Outline of Study Findings

Table 1-4.1 Survey Findings for Nauru

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Salinization of wells in coastal areas and interference of rainwater use due to drought, ② Shortage of water supply trucks for carrying potable water following desalinization treatment, ③ Groundwater contamination caused by domestic wastewater, and water quality problems in rainwater tanks

Meteorological observation and disaster prevention: ① Coastal erosion around the airport, ② Traffic interruptions caused by overtopping waves, ③ Meteorological observation data are directly sent to donors and not utilized in Nauru.

b) Future impacts

Water resources: ① Advance of salinization of coastal groundwater due to rise in the sea level and decline in rainfall, ② Increasingly serious water shortages during the dry season

Meteorological observation and disaster prevention: ① Expansion of damage from submergence of coastal roads due to increase in sea level

(2) Government Measures and Cooperation Needs

a) Government measures

In Nauru, the NAPA has not yet been decided, however, the National Committee on Climate Change has been organized and the following steps are being examined regarding climate change: ① Strengthening of the National Meteorological and Hydrological Service, ② Examination of climate change environmental impact adaptation measures, ③ Implementation of stable water supply, ④ Maintenance of coastal roads, ⑤ Groundwater development and management planning, ⑥ Compilation of disaster management plan by the Disaster Management Committee

b) Cooperation needs heard from the local government

Water resources: ① Dry season water shortage countermeasures, ② Sanitary management technology in water resources management

Meteorological observation and disaster prevention: ① Learning and enhancement of forecasting technology, ② Enlightenment activities concerning climate change and disaster prevention, and training in broadcasting

(3) Donor support conditions

Water resources: ① Integrated water resources management project by the EU, ② Water resources survey by GEF, ③ Seawater desalinization project and rainwater tank supply by AusAID, ④ Rainwater tank supply based on Japanese grassroots grant aid

Meteorological observation and disaster prevention: ① Atmospheric radiation observation by the US, ② Sea level and climate monitoring project by AusAID, ③ Coastal erosion survey (analysis around airports and fishing ports, seabed terrain survey) by SOPAC

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Appropriate water utilization** (Underground storage of rainwater)

II **Meteorological observation capacity building concerning climate change** (Training of meteorological and disaster forecasters, improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Compilation of disaster (drought) countermeasures criteria, ②Dissemination and enlightenment activities, ③Port construction)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ③Dissemination and enlightenment activities ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

Table 1-4.2 Survey Findings for Kiribati

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Salinization of wells that provide the public water supply in the capital Tarawa, ②Salinization of well water in small remote islands

Meteorological observation and disaster prevention: ①Coastal erosion caused by rising sea level (Nippon Causeway, Otintaai Hotel seawall, area around Bikenibeu Primary School, area around Tungaru Central Hospital, area around radio station), ② Destruction of breakwater at Bairiki fishing port, ③ Shortage of meteorological observation stations, ④ Inefficiency of meteorological observations by the Meteorological Service and Ministry of Public Works and Utilities, ⑤ Deficiencies in the meteorological observation data communication system

b) Future impacts

Water resources: ① Prolonging of droughts and impact on rainwater use due to climate change, ② Shrinkage of the freshwater lens, salinization of well water and water shortages in Tarawa and small remote islands due to prolonging of drought,

Meteorological observation and disaster prevention: ① Destruction of coastal facilities due to higher sea level and greater frequency of high waves due to climate change, ② Development of coastal areas due to population growth, and increased vulnerability to coastal erosion as a result of this

(2) Government Measures and Cooperation Needs

a) Government measures

The Office of President has compiled the Kiribati Adaptation Program (KAP), while the Ministry of Environment, Land and Agricultural Development has compiled the NAPA. Contents of the KAP are as follows: ① Compilation of policies and management of information, ② Physical structures and ecosystems in land use, ③ Sources of freshwater, ④ Development of response capability in remote islands and on the community level, and so on. Meanwhile, contents of the NAPA are as follows: ① Water source adaptation project, ② Improvement of simple wells, ③ Coastal area management and strengthening of adaptability, ④ Strengthening of climate change information and monitoring, ⑤ Enhancement of meteorological services, ⑥ Coastal conservation and improvement of causeways, and ⑦ Effective participation in local and international forums concerning climate change, and so on. The KAP was compiled under the direct jurisdiction of the Office of President, while the NAPA was prepared by the Ministry of Environment, Land and Agricultural Development acting as the implementing agency. The KAP and NAPA are coordinated through the Office of President acting as the decision making body for both.

b) Cooperation needs heard from the local government

Water resources : ① Conservation of the freshwater lens amidst rising sea level, ② Groundwater development and construction of water supply facilities in North Tarawa, ③ Improvement of water supply on remote islands, ④ Introduction of seawater desalinization plants, ⑤ Development and technical capacity building of personnel in charge of water resources management

Meteorological observation and disaster prevention : ① Installation of meteorological observation stations, observation instruments and an observation data communications network on remote islands, ② Capacity building with respect to meteorological observation and forecasting, ③ Establishment of disaster and disaster prevention radio communications network, ④ Warnings of tornadoes and abnormal tides on remote islands, ⑤ Coastal erosion countermeasures in Tarawa (radio broadcasting stations, Tungaru Central Hospital, Bonriki International Airport, causeways), ⑥ Coastal erosion countermeasures on remote islands

(3) Donor support conditions

Water resources : ① Project with emphasis on integrated water resources management based on EU and GEF funding (currently under implementation). The GEF project also includes wastewater management. ② The ADB supports the remote islands development center. ③ AusAID plans to implement a survey of water resources on South Tarawa and remote islands. ④ The EU plans to implement a groundwater management survey of the Gilbert Islands.

Meteorological observation and disaster prevention : ① SOPAC is supporting community risk programs. ② The World Bank and AusAID plan to implement coastal erosion countermeasures in KAP2. ③ Sea level and climate monitoring project and two other meteorological projects are being implemented by AusAID. ④ A survey of aggregate materials extraction has been implemented by SOPAC under EU support.

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Appropriate water utilization** (①Improvement of water supply in South Tarawa through groundwater development in North Tarawa and construction of facilities ②Conservation of freash water lens through promoting rainwater recharging via community facilities ③Improvement of water supply on remote islands ④Sanitary management and enlightenment activities in water management targeting communities ⑤Water resources management personnel training and capacity building)

II **Capacity building with respect to meteorological observation regarding climate change** (①Establishment of the meteorological observation network ②Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Coastal erosion countermeasures at Tungaru Hospital, the causeway and surrounding areas on Tarawa ③Coastal erosion countermeasures at radio stations ④Information collection on disaster countermeasures and coastal erosion ⑤Capacity building of the National Disaster Committee ⑥Establishment of the disaster/disaster prevention radio network ⑦Integrated hazard map preparation and coastal management capacity building ⑧Disaster broadcasting capacity building ⑨Installation of early warning systems ⑩Dissemination and enlightenment activities ⑪Technical improvement of coastal erosion countermeasures on remote islands)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ③Dissemination and enlightenment activities ④Disaster broadcasting capacity building ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

Table 1-4.3 Survey Findings for Papua New Guinea

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Water shortages caused by salinization of coastal wells and reduced rainfall in droughts, ② Insufficient water supply due to reduced storage in the dam reservoir for Port Moresby

Meteorological observation and disaster prevention: ① Submergence and evacuation of residents (Bougainville) due to rising sea level, ② High tides, coastal erosion, inundation and submergence (Manus Province), ③ Salinization of soil and abandonment of land due to seawater, ④ High tide inundation and fallen trees (Gulf Province), ⑤ Worsening of tsunami damage due to cutting of mangroves, ⑥ Shrinkage of islands due to extraction of aggregate materials on coral islands (northern remote islands)

b) Future impacts

Water resources: ① Due to the impact of climate change, salinization of groundwater will grow worse in coastal areas. ② The effects of drought will worsen in mountainous parts, and water supply in the capital Port Moresby, provincial towns and district towns will suffer due to river water and groundwater shortages.

Meteorological observation and disaster prevention: ① Inadequacy of facilities for meteorological observation and disaster information transmission will aggravate damage. ② Due to increased rainfall caused by climate change, river flooding will occur and lead to greater damage of roads and bridges in mountainous areas. ③ Growing frequency of natural disasters caused by climate change will badly affect the tourism industry.

(2) Government Measures and Cooperation Needs

a) Government measures

Although PNG has not compiled a NAPA, it has established a Office of Climate Change and Environmental Sustainability directly under the Office of the Prime Minister, and the setup for responding to climate change has been prepared over the entire government. ① Concerning water resources, the Ministry of Environment and Conservation implements water quality monitoring for the purpose of water resources management. ② Concerning disaster prevention measures, the National Disaster Center implements climate change countermeasures.

b) Cooperation needs heard from the local government

Water resources : ① Fact-finding study of salinization in coastal areas, ② Study geared to selecting alternative water resources, ③ Construction of a nationwide hydrological observation network, ④ Establishment of sustainable water systems for coastal communities

Meteorological observation and disaster prevention : ① Installation of river flow observation station, ② Hazard mapping and implementation of vulnerability assessment, ③ Supply of GIS instruments and improvement of technology, ④ Training of engineers skilled in coastal adaptation and mitigation measures in small remote islands, ⑤ Construction of the meteorological observation network, ⑥ Evacuation forecasting and warning system

(3) Donor support conditions

Water resources : The EU is currently implementing the Integrated Water Resources Management Programme. Also, the GEF-funded sustainable and integrated water resources securing and wastewater management project is planned.

Meteorological observation and disaster prevention : ① AusAID is currently implementing sea level and climate monitoring, the climate forecasting project, the climate data redress project, the monitoring system project and so on. ② The ADB has decided to support the investment program for highlands road construction.

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Development of alternative water sources and integrated water resources management** (①Salinization countermeasures capacity building and master plan preparation ②Community development of ponds ③Water storage projects linked to micro hydropower)

II **Capacity building with respect to meteorological observation regarding climate change** (①Establishment of the meteorological observation network ②Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Organizational strengthening (functional strengthening and expansion) of the National Disaster Center ③Organizational strengthening of the Office of Climate Change and Environmental Sustainability (improvement of coordination capacity) ④Installation of equipment for application to disaster broadcasting ⑤Integrated hazard map preparation ⑥Installation of early warning systems ⑦Disaster broadcasting capacity building ⑧Information collection on disaster countermeasures and coastal erosion ⑨Bridge and national highway disaster prevention measures ⑩Dissemination and enlightenment activities)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Integrated hazard map preparation and coastal management capacity building ③Dissemination and enlightenment activities ④Disaster broadcasting capacity building ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

Table 1-4.4 Survey Findings in Vanuatu

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Instability of water supply due to pollution of water sources caused by infiltration by domestic wastewater at times of heavy rain and deterioration of reservoirs and water pipes. ② Weak water quality control setup (Luganville). ③ Salinization of water sources and lack of information concerning the state of water use on remote islands

Meteorological observation and disaster prevention: ① Poor drainage in the capital Port Vila, ② River flooding (Mere River in the capital and rivers on Santo Island), ③ Coastal erosion and high tide damage on coastal lowlands (remote islands), ④ Staff shortages in the National Disaster Management Office and inadequate disaster prevention activities, ⑤ Meteorological observation instruments

b) Future impacts

Water resources: ① Against the background of climate change, risk of pollution of water sources due to infiltration of domestic wastewater at times of inundation (Luganville, communities), ② Advancing salinization of groundwater due to rising sea level (small and remote islands)

Meteorological observation and disaster prevention: ① Regular occurrence of flash flooding caused by climate change, ② Coastal erosion caused by rising sea level and high waves at times of cyclones, and damage to coastal areas and infrastructure due to high waves, ③ Magnification of damage caused by inadequacy of meteorological observation instruments and information communication, ④ Negative impact on tourism of higher frequency of natural disasters caused by climate change.

(2) Government Measures and Cooperation Needs

a) Government measures

The National Action Committee on Climate Change (NACCC) was established in the latter part of the 1990s and is dealing with climate change issues. The ① Integrated Water Resources Management Plan and ② National Action Plan for Disaster Risk Mitigation and Disaster Management, have been compiled and adaptation measures based on an integrated coastal management plan are being examined.

b) Cooperation needs heard from the local government

Water resources : ① Development of new water sources, construction and rehabilitation of distribution reservoirs and pipes, enhancement of water quality management capacity in Luganville, ② Water quality assessment and water supply and demand survey on the national scale, ③ Development of alternative water sources and establishment of a system for the emergency transport of water by boats in areas where natural disasters have rendered rainwater undrinkable

Meteorological observation and disaster prevention: ① Support for organizational strengthening of the NDMO, ② Improvement of disaster broadcasting capability, ③ Support programs for dissemination and enlightenment activities, ④ Expansion of meteorological observation facilities and installation of early warning system for responding to flooding, ⑤ Disaster countermeasures utilizing satellite image analysis, ⑥ Improvement of urban drainage functions and flood countermeasures on Mere River, ⑦ Coastal erosion countermeasures and participation in relocation programs, ⑧ Disaster prevention measures on coastal national roads and bridges

(3) Donor support conditions

Water resources : Integrated Water Resources Management (IWRM), Hydrological Cycle Observing System (HYCOS), Water Security Project (WSP), and construction of water supply facilities, etc. are being implemented.

Meteorological observation and disaster prevention : ① Compilation of the Disaster Risk Mitigation and Disaster Management National Action Plan (SOPAC), Integrated Coastal Management Plan (GEF), Second National Communication (UNDP/GEF), ② Implementation of a highland relocation program as a countermeasure to coastal erosion (CIDA) ③ Sea level monitoring and climate forecasting project is under implementation (AusAID)

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Integrated water resources management and emergency water supply** (①Nationwide emergency water shortage countermeasures ②Improvement of nationwide water supply and demand)

II **Capacity building with respect to meteorological observation regarding climate change** (Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Organizational strengthening of the National Disaster Management Office ② Installation of early warning systems ③Disaster broadcasting capacity building ④Construction of urban drainage facilities ⑤ Coastal erosion countermeasures ⑥Compilation of infrastructure design criteria for disaster prevention ⑦Integrated hazard map preparation ⑧Dissemination and enlightenment activities ⑨Coastal highway and bridge disaster prevention measures ⑩ Information collection on disaster countermeasures and coastal erosion ⑪River flooding countermeasures ⑫Construction of regional city drainage facilities

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (②Integrated hazard map preparation and coastal management capacity building ③ Dissemination and enlightenment activities ⑤Information collection on disaster countermeasures and coastal erosion ⑥ Establishment of coastal engineering basic courses)

Table 1-4.5 Survey Findings in the Independent State of Samoa

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Contamination caused by turbidity of water sources and infiltration of domestic wastewater at times of rainfall, ② Shortages of water quality management personnel and management technology, and inadequate water quality control instruments

Meteorological observation and disaster prevention: ① Inundation caused by poor drainage in the capital Apia, ② Interruption of urban functions in the capital due to flash floods, ③ Coastal erosion in northeastern Upolu Island, ④ High tide inundation and submergence of roads in coastal areas, ⑤ Shortage of personnel and poor disaster prevention activities of the National Disaster Management Office, ⑥ Shortage of early warning instruments and low forecasting technology capability

b) Future impacts

Water resources: ① Instability of water supply due to reduced capacity of purification plants at times of heavy rain caused by climate change, ② Higher risk of water sources turbidity at times of heavy rain.

Meteorological observation and disaster prevention: ① Aggravation of damage caused by inadequate meteorological observation and disaster information transmission , ② Regular occurrence of flash floods and higher risk of sediment disasters due to climate change, ③ Negative impact on tourism because of traffic interruptions due to inundation of coastal roads

(2) Government Measures and Cooperation Needs

a) Government measures

The government compiled the NAPA in 2005 and the Strategy for the Implementation of the NAPA in 2006. Priority issues are: water resources, forest conservation, climate and sanitation collaboration program, and early warning system. ① The National Water Resource Plan (2007-2017) has been compiled and water resources development and sewerage construction are being implemented. ② The Coastal Infrastructure Management Plan and National Disaster and Crisis Management Plan have been compiled and disaster prevention measures are being conducted.

b) Cooperation needs heard from the local government

Water resources : ① Construction of additional distribution reservoirs and implementation of countermeasures for unaccounted for water in order to stabilize supply of living water in Apia, ② Development of new water sources and construction of water supply facilities in rural areas, ③ Strengthening of water quality management capacity

Meteorological observation and disaster prevention : ① Support for strengthening of NDMO organization, ② Capacity building regarding assessment of the cost of damages to public facilities, ③ Urban river countermeasures on Visigano River (Apia), ④ Installation of early warning systems for flooding, ⑤ Expansion of meteorological observation facilities and enhancement of meteorological forecasting capacity, ⑥ Construction of disaster countermeasure infrastructure on the community base (including coastal erosion countermeasures)

(3) Donor support conditions

Water resources : The EU is implementing the Integrated Water Resources Management Program via SOPAC. It is supporting a water supply plan including the development of water sources for Apia and provincial areas. GEF is implementing a water management project on Savai'i Island.

Meteorological observation and disaster prevention : ① AusAID is implementing sea level and climate monitoring, a climate forecasting project, a monitoring system project and so on. ② Under support from the World Bank, a coastal infrastructure project and infrastructure assets management project have been continued since 1999, and a cyclone emergency recovery project, risk management component, is being implemented.

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Integrated water resources management and emergency water supply** (①Nationwide emergency water shortage countermeasures ②Improvement of nationwide water supply and demand)

II **Capacity building with respect to meteorological observation regarding climate change** (①Expansion of meteorological observation facilities ②Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Organizational strengthening of the National Disaster Management Office ②Installation of early warning systems ③Urban river flooding countermeasures ④Disaster broadcasting capacity building ⑤Compilation of infrastructure design criteria for disaster prevention ⑥Integrated hazard map preparation ⑦Dissemination and enlightenment activities ⑧Coastal highway and bridge disaster prevention measures ⑨Community infrastructure construction works ⑩Information collection on disaster countermeasures and coastal erosion ⑪Disaster assessment capacity building)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Integrated hazard map preparation and coastal management capacity building ③Dissemination and enlightenment activities ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

Table 1-4.6 Survey Findings in Tonga

Vulnerability and Needs concerning Climate Change

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: ① Since the water for public supply in Tongatapu Island is hard and has high salinity, people depend on rainwater for potable water. ② Instable water supply due to insufficient flow and pressure, ③Dependence of provincial water supply on rainwater, ④ Shortage of personnel in Tonga Water Board

Meteorological observation and disaster prevention: ① Inundation caused by poor drainage in the capital Nuku'alofa, ② Coastal erosion (around the lagoon in Nuku'alofa, and Fua'amotu), ③ High tide inundation (capital region and Lifuka Island, etc.), ④ Delays in disaster prevention communications due to budget and personnel shortages in the National Emergency Management Office, and slow establishment of provincial organizations, ⑤ Shortage of personnel, deterioration of facilities and weak forecasting technology in the Meteorological Service.

b) Future impacts

Water resources: ① It is forecast that droughts will occur more frequently and rainwater for drinking purposes will run short. ② There is greater risk of more frequent power cuts caused by various disasters, leading to interruption of stable water supply.

Meteorological observation and disaster prevention: ① Due to climate change, it is forecast that cyclones will hit land more frequently, and that the capital Nuku'alofa will experience reduced urban functions due to inundation. ② Expansion of high tide inundated areas due to rising sea level and cyclones, ③ Aggravation of damage due to weak meteorological observation and poor communications.

(2) Government Measures and Cooperation Needs

a) Government measures

Tonga ratified the United Nations Framework Convention on Climate Change in 1998. ① Tonga has compiled a Climate Change Implementing Schedule in which it has formulated and prioritized concrete steps for natural disasters, coastal environmental conservation, sustainable agriculture and so on. ② The Second National Communication with planning period of 2006~2015 has been compiled and is being implemented with support from the GEF. Tonga does not formulate NAPA because Tonga is not latest developed country. However, above policies corresponds to the NAPA

b) Cooperation needs heard from the local government

Water resources: ① Construction of water supply facilities and strengthening of water quality management capacity with a view to achieving stable water supply with stable water quality in the capital, ② Promotion of efficient use of water resources through water leakage countermeasures and water conservation, etc., ③ Nationwide water supply and demand survey and water quality survey

Meteorological observation and disaster prevention: ① Strengthening of functions of the National Emergency Management Office and promotion of community disaster prevention activities, ② Construction of multipurpose cyclone shelters, ③ Establishment of a disaster prevention radio network, ④ Expansion of meteorological observation facilities, installation of early warning systems for flooding, and enhancement of weather forecasting technology, ⑤ Measures to counter coastal erosion, high tide countermeasures, construction of drainage facilities (Tongatapu Island), etc.

(3) Donor support conditions

Water resources: The EU is implementing the Risk Reduction Project in the field of water supply (repair of pumps for water supply wells, measures for prevention of contamination of water sources, water softening measures, rehabilitation of chlorine facilities, strengthening of water quality monitoring).

Meteorological observation and disaster prevention: ① AusAID has implemented equipment supply (emergency generators, V-Sat System, etc.) and training at its headquarters (human resources development, emergency response setup, etc.) for the Meteorological Service.

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Development of alternative water source and integrated water resources management** (①Nationwide emergency water shortage countermeasures ② Survey of groundwater reserves and monitoring of water quality ③ Water leakage countermeasures and water saving ④Improvement of nationwide water supply and demand)

II **Meteorological observation capacity building relating to climate change** (Training of meteorological and disaster forecasters, improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Organizational strengthening of the National Emergency Management Office ② Installation of early warning systems ③Disaster broadcasting capacity building ④Construction of multipurpose cyclone shelters ⑤Compilation of infrastructure design criteria for disaster prevention ⑥Integrated hazard map preparation ⑦ Dissemination and enlightenment activities ⑧Construction of urban drainage facilities ⑨High tide countermeasures ⑩ Coastal highway and bridge disaster prevention measures ⑪Information collection on disaster countermeasures and coastal erosion ⑫Coastal erosion countermeasures)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (②Integrated hazard map preparation and coastal management capacity building ③ Dissemination and enlightenment activities ④Disaster broadcasting capacity building ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

Table 1-4.7 Survey Findings in the Solomon Islands

(1) Current Vulnerability and Future Impacts

a) Current conditions

Water resources: Salinization of coastal well water and interruption of rainwater utilization

Meteorological observation and disaster prevention: ① Inundation, evacuation of residents and road submergence resulting from rise in sea level, ② Loss of human life, damage to roads and bridges due to torrential rain, ③ Inadequate meteorological observation stations and meteorological and disaster forecasting technology

b) Future impacts

Water resources: ① Serious depletion of water resources due to reduced rainfall (climate change), cutting of forests for farmland and reduction of water source recharging areas, ② Advancing salinization of coastal groundwater due to rise in sea level

Meteorological observation and disaster prevention: ① Expansion of coastal road inundation damage due to rising sea level, ② Frequent occurrence of flooding and sediment disasters due to torrential rain

(2) Government Measures and Cooperation Needs

a) Government measures

Seven areas of activity are specified in the NAPA: ① Agriculture and food security, water and sanitation, health, education, ② Submersion countermeasures on lowland and artificial islands, ③ Solid waste management, ④ Coastal erosion, ⑤ Fisheries and fishery resources conservation, ⑥ Infrastructure construction, and ⑦ Tourism. Donor support has only been secured for ①, while the government seeks donor support for the remaining items from now on.

b) Cooperation needs heard from the local government

Water resources： ① Measures for protection of water supply facilities at times of torrential rain, ② Well salinization countermeasures, ③ Measures to counter spring water shortages in the dry season, ④ Water source conservation enlightenment activities, ⑤Village water supply sanitary management

Meteorological observation and disaster prevention： ① Measures to counter disasters caused by localized torrential rain, drought and coastal erosion, etc. ② Measures to counter flooding of trunk roads (bridges) and submergence and erosion of coastal roads (regular occurrences with the spring tide), ③ Construction of meteorological observation stations, ④Support for establishment of disaster-related legislation and standards of conduct, ⑤Establishment of emergency communication network for use at times of disaster, ⑥ Compilation of infrastructure design criteria, ⑦ Enlightenment activities concerning disaster prevention

(3) Donor support conditions

Water resources： The EU and GEF are implementing a study with emphasis on integrated water resources management.

Meteorological observation and disaster prevention： Pacific wide area projects include the disaster risk mitigation programme by SOPAC and community-based disaster risk mitigation by AusAID. In the meteorological field, the SREP and WMO meteorological observation system and forecasting program is being implemented over the whole Pacific region.

(4) Direction of cooperation geared to mitigation of vulnerability

Country-Separate

I **Integrated water resources management** (①Groundwater improvement ②Water utilization improvement)

II **Meteorological observation capacity building relating to climate change** (Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology)

III **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Organizational strengthening of the National Disaster Management Office ③Dissemination and enlightenment activities ④Disaster broadcasting capacity building ⑤Information collection on disaster countermeasures and coastal erosion ⑥Integrated hazard map preparation and coastal management capacity building ⑦Installation of early warning systems ⑧Coastal highway and bridge disaster prevention measures)

Wide Area

I **Meteorological observation capacity building relating to climate change** (①Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology ②Establishment of a meteorological observation network and sharing of observation data)

II **Climate change risk management** (①Compilation of infrastructure design criteria for disaster prevention ②Integrated hazard map preparation and coastal management capacity building ③Dissemination and enlightenment activities ④Disaster broadcasting capacity building ⑤Information collection on disaster countermeasures and coastal erosion ⑥Establishment of coastal engineering basic courses)

CHAPTER 2 Conditions Regarding the Impacts of Climate Change

2-1 Outline of Climate Change in the Target Region

(1) Changes in Sea Level and Weather Conditions

When considering the impacts of climate change, it is necessary to examine changes in meteorological phenomena via comparison over units of 100 years. However, since Samoa was the first country in this region to gain independence in 1962 while the other countries only became independent in the 1970s and 1980s, they do not possess adequate data to substantiate the impacts of climate change.

According to the SOPAC report entitled Pacific Country Report; Sea Level & Climate, since 1992, when tide gauges were installed under the South Pacific Sea Level and Meteorological Monitoring Project by AusAID, the average annual sea level has increased by 5.3 mm in Kiribati, 6.5 mm in Nauru, 6.2 mm in Papua New Guinea, and 7.0 mm in Tonga[1]. Moreover, average temperature in Oceania increased by 0.2~1.0℃[2] between 1970 and 2004, while the number of "strong tropical cyclones" of Category 4 and 5 in the South Pacific increased from 85 between 1975~1989 to 116 between 1990~2004, and the ratio of strong cyclones out of the total increased from 25% to 41%[3]. Ongoing meteorological observations such as these are giving a clearer picture of the meteorological changes taking place in the region.

(2) Level and Forecasting of Impacts

According to the Fourth Assessment Report issued by the Intergovernmental Panel on Climate Change (IPCC) in November 2007, warming of the climate system is unequivocal and it is forecast that the following impacts will be experienced by small island nations including those in the target area:

① Increasing sea level will aggravate coastal disasters such as inundation, high tides and erosion, thereby threatening the basic infrastructure, residential land and public facilities that support local communities.

② Coastal deterioration caused by erosion and coral blanching will impact local resources.

③ By the middle of this century, water resources will become so depleted that the demand for water in dry seasons will not be satisfied.

④ Temperature increase will lead to infiltration by non-indigenous species in middle and high latitude areas.

In island nations, natural ecosystems such as mangroves and coral reefs play a major part in the formation of land, however, the IPCC 4th Assessment Report states that mangroves and coral reefs are especially prone to the impacts of climate change and that, since residents and infrastructure are strongly exposed to the risks of rising sea level and higher tides, human health is also badly impacted. Furthermore, since rising sea level has combined with extreme phenomena such as changing rainfall patterns in recent years, it is projected that this will generate negative synergy and turn climate change into a major threat in the target area.

For example, in the event where a 0.5 m increase in sea level combines with the waves caused by a cyclone with a 50 year probability, there is a strong possibility that the port facilities at Apia in Samoa will experience overtopping waves, wharf damage and hinterland flooding[4]. Taking another case, a 10% drop in average rainfall by 2050 could lead to a 20% reduction in the size of the freshwater lens in Tarawa Atoll in Kiribati, while the physical shrinkage of the freshwater lens caused by land depletion in line with rising sea level will cause the freshwater lens in the atoll to shrink by 29%[5].

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[1] AusAID/SOPAC, Pacific Country Report Sea Level & Climate: Their Present State Kiribati, June 2006
[2] IPCC, Fourth Assessment Report (Consolidated Report)
[3] Webster, P.J., et al., 2005: Changes in tropical cyclone number, duration and intensity in a warming environment. Science, 309, 1844-1846. reprinted with permission from AAAS
[4] IPCC Fourth Assessment Report (Report of Working Group II)
[5] IPCC, Fourth Assessment Report (Report of Working Group II)

In the Study, regarding areas considered prone to the effects of climate change, field surveys and discussions with concerned government agencies were carried out in order to confirm vulnerability to climate changes, confirm the needs of local governments, and examine the future direction of cooperation by the Government of Japan. The results of examination are described in Chapter 3, while this chapter describes the vulnerability of each country as well as the needs and future impacts ascertained in discussions.

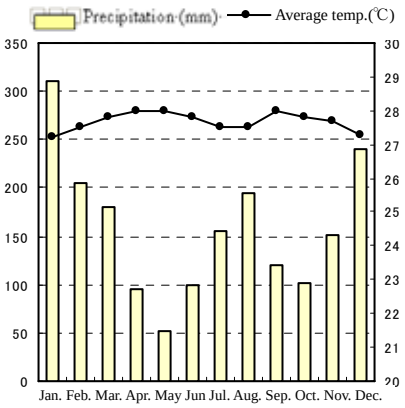
2-2 Results of Surveys in Each Country

2-2-1 Republic of Nauru

(1) General Condition

1) Population

The population of Nauru is approximately 10,000 and comprises people of mostly Micronesian descent, and there are also some workers and their families for phosphorus mining from Kiribati and Tuvalu. Number of Worker from foreign countries is decreasing due to decrease in mining project, because amount of mine has been reduced. People mainly stay along coastal area; however, residential area is expanding toward inland area. It is necessary to monitor a long-term change in population pressure caused by change in residential area with increasing population.



Source：WMO

Figure 2-2.1 Temperature and Rainfall in Nauru

2) Climate

Nauru has a tropical marine climate with annual mean temperature of approximately 28℃, daily minimum temperature of 24℃ and maximum temperature of 32℃. The rainy season lasts from November to February and annual rainfall is approximately 2,000 mm although fluctuations are large between each year.

3) Geography

Nauru, located approximately 40 km south of the Equator, comprises a single coral island with a circumference of 19 km. The land area is 21km^2 while the exclusive economic zone covers 310,000km^2. Nauru is separated from other islands: it is approximately 500 km from Kiribati in the northeast and 1,000 km from the Solomon Islands in the southwest. Altitude at the highest point of the island is 65 m, and the central part of the island contains phosphate mineral.

4) Past Major Natural Disasters

Nauru does not experience any major natural disasters such as cyclones, high tides and tsunami. Figure 1 shows annual rainfall. Assuming 500 mm/year or less to be a dry year, dry years have recently occurred in 1949 (218 mm) and 1998-2000 (463 mm/year on average). As is shown in Figure 1, dry years have become more conspicuous in recent years.

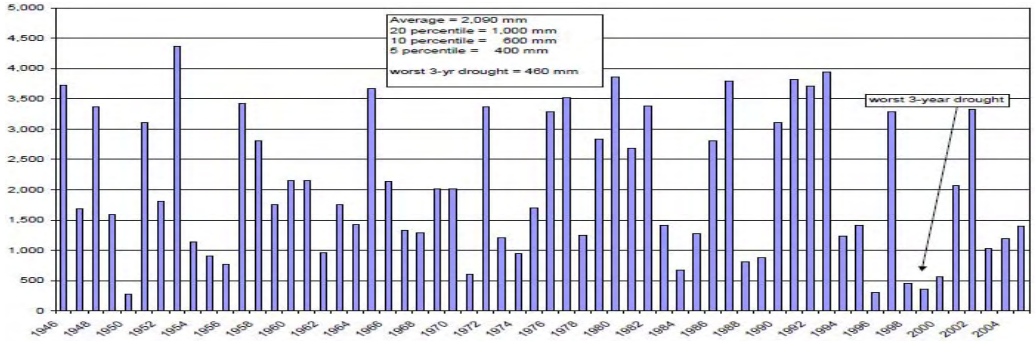


Figure 2-2.2 Annual Rainfall in Nauru

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

Annual precipitation in Nauru is roughly 2,000 mm, however, yearly fluctuations are large (300mm~4,000mm over the past 85 years) [1] and water shortages are particularly acute in dry

[1] National Committee on Climate Change, Republic of Nauru, 1st National Communication – 1999 "Under the United

years. There are also seasonal fluctuations, and water shortages become critical during the dry seasons (November to February) of dry years.

a) Water resources

① Water supply in cities and rural areas

During periods when rainfall is reduced, groundwater salinity increases. Accordingly, groundwater is used as living water for purposes other than drinking. As a result, there are critical shortages of potable water during the dry season, and at such times the government supplies potable water produced by seawater desalinization plants. Desalinization plants were introduced to Nauru by AusAID. Among them, large-scale desalinization plant (treatment capacity was 1,100ton/day) was operated until 2002. After that plant was out of order, small-scale reverse-osmosis plants (120,000ℓ/day×2 sets) have been operated until now.

Photo 2-2.1 Water Supply by a Water Truck

Concerning water quality, groundwater is becoming contaminated by domestic wastewater and water quality inside water tanks is also a problem.

② Water resources management organization

Public water supply in Nauru is operated by Nauru Public Facilities Department. Seawater is treated in desalinization facilities and supplied in water trucks, however, because the number of trucks is limited (only two government trucks and one truck belonging to a private company), water deliveries take a long time. Accordingly, many people directly come to the desalinization plant to get water.

The Nauru Rehabilitation Corporation conducts surveys of the quantity and quality of groundwater resources in the phosphate rock mining district, however, a problem exists in that there are no data concerning the number of wells and pumped volumes during the era before Nauru gained independence.

The Department of Health analyzes the quality of potable water, however, it only conducts general bacteria and coliform analyses using basic analysis kits with low accuracy, and it does not implement periodic water quality analysis resulting in unreliable monitoring of water quality. Due to the shortage of analysis apparatus and personnel, water quality analysis tests are inadequate in terms of both quantity and quality.

b) Meteorological observation and disaster prevention

① Meteorological observation station and pre-existing disasters in Nauru hardly any damage is caused by cyclones and high tides, etc.

There is one meteorological observation station in Nauru, and this only implements data measurement. Concerning disasters, hardly any damage is caused by cyclones and high tides, etc.

There is one meteorological observation station in Nauru. The data are directly sent to the meteological agencies in Australia and the United States. Since these data and the data obtained from the Meteorological Srevice in Fiji are not utilized for making local forecasts, Nauru does not possess weather forecasting capability.

At the First Country Report (NC) concerning climate change that was presented by Nauru in national conference held by United Nation in 1999, coastal erosion and flooding caused by poor drainage in coastal areas were pointed to as impacts of climate change, however, no plan or strategy was formulated based on the concrete examination at the NC. Accordingly, it is

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Nations Framework Convention on Climate Change", October 1999

unclear how the items pointed out have been followed up.

Coastal erosion is occurring around the reclaimed area for extension to the airport runway; moreover, overtopping waves are arising traffic obstruction on the coastal road from the east to the north.

At the time of the tsunami in 2007, all island dwellers were able to evacuate following the order. The police carried the order to every household partly with radio broadcastiong, it took around 25 minutes for the evaluation to be completed.

Photo 2-2.2
Area around Airport Runway Landfill

② Organization in charge of meteorological observation and disaster prevention

Observations for gauging climate changes are implemented at the atmospheric radiation observatory. However, the findings from here are not sufficiently utilized in weather forecasting and so on.

The Law of National Coordination, which corresponds to the Disaster Management Act, has been formulated. The Disaster Management Committee, composed of the heads of five organizations under the President, has been organized and this is currently in the process of compiling evacuation plans and disaster management plans.

(b) Future impacts

a) Water resources

In the event where rainfall fluctuations become larger in future, it is likely that the groundwater level during the dry season will decline, salinity of well water will increase, and shortages of potable water will be exasperated.

b) Meteorological observation and disaster prevention

Concerning disasters caused by climate change, in areas where low-lying coastal roads are only 1 m or so above the wave breaking height, it is possible that rising sea level and high waves will disable traffic and cause damage to roads. Since the coastal road that runs around the whole island is an arterial route, if this becomes damaged, there are likely to be effects on the transportation of supplies and so on.

2) Government Measures and Cooperation Needs

(a) Government measures

To coincide with the first NC, the National Committee on Climate Change was organized, and this body conducts observations and forecasts. Also, the Department of Commerce, Industry and Environment is taking the initiative in examining adaptation measures regarding the environmental impacts of climate change. Moreover, concerning meteorological observations, it is proposed that the National Meteorological and Hydrological Service be strengthened with a view to consolidating and utilizing observation data and enhancing capacity.

The NAPA has not yet been formulated, however, the Department of Commerce, Industry and Environment is taking the initiative in examining adaptation measures regarding the environmental impacts of climate change.

In its National Sustainable Development Strategy 2005~2025, the Government of Nauru has made the stable supply of potable water and living water for all households and water supply for businesses as the primary goal in the water resources field, intending formulation of groundwater development and management plan based on several studies. As strategies for realizing this goal, it has adopted the development of technical, organizational and financial management capacity as secondary goals. However, the assessment carried out in September 2008 pointed to a lack of cooperation, financial and capacity constraints.

Concerning the disaster field, the goal is to maintain roads (coastal) that are prone to damage

from climate change in a good condition.

Moreover, it is scheduled to compile a groundwater development and management plan based on various survey findings in the future.

As for dissemination and education activities and warnings concerning climate change, the Government Information Office and Nauru Media Bureau are involved, however, the Government Information Office has only just been established and its setup is still not clear.

(b) Cooperation needs

Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management
- Dry season water shortage countermeasures
- Sanitary management technology in water resources management

b) Meteorological observation and disaster prevention
- Learning and enhancement of forecasting technology
- Enlightenment activities concerning climate change and disaster prevention, and training in broadcasting

2-2-2 Republic of Kiribati

(1) General Condition

1) Population

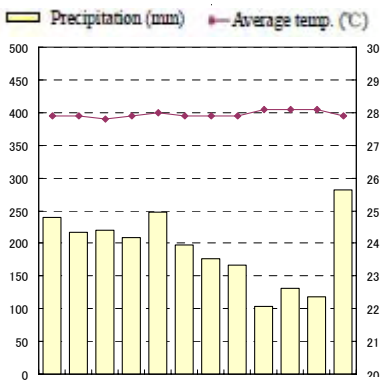
Kiribati has a population of approximately 92,000, of which 94% lives in the Gilbert Islands which include the capital Tarawa. The remaining 6% almost all live on Christmas Island, biggest atoll in the world, which accounts for 48% of the national land area and also possesses the largest coral reef. Around 50 people live on Canton Island in the Phoenix Islands. Forty thousand people are living in south Tarawa, where it is crucial problem that vulnerability to climate change will be increased by growing population pressure.

2) Climate

Kiribati has a tropical climate over its whole area, and monthly and daily fluctuations in temperature are small. Rainfall exceeds 3,000 mm in the wettest parts. The capital Tarawa has temperature of 27～28℃ and annual rainfall of approximately 2,000 mm. Rainfall is lowest on Christmas Island, where it is around 700 mm.

3) Geography

Kiribati is composed of the Gilbert, Phoenix and Line island groups possessing 33 atoll islands. Its total land area is 730km^2 and its exclusive economic zone covers 3,500,000 km^2. The capital Tarawa is situated approximately 200 km north of the Equator and is roughly midway between Hawaii and Brisbane in Australia.



Source: Meteorological Service

Figure 2-2.3 Temperature and Rainfall in Tarawa

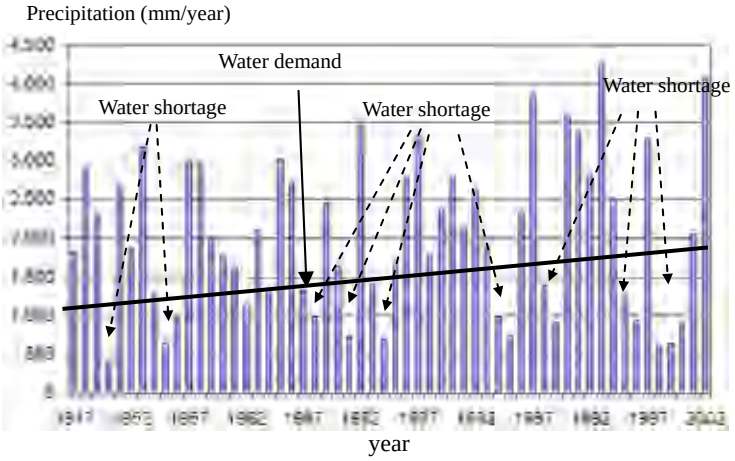
4) Past Major Natural Disasters

Kiribati is experiencing damage from high tides and dry weather. Figure 2 indicates the relationship between annual rainfall and demand in Tarawa. Kiribati experienced serious droughts in 1998 and 1999. The relationship between water demand and rainfall varies greatly each year, however, water shortages have become more serious in recent years.

Table 2-2.1 Past Major Natural Disasters

Date	Classification	Fatalities	People Affected
2008, Dec.	High tide	-	85
Feb.	Drought	-	
2005, Feb.	High tide	-	
1999, Mar.	Drought	-	84,000
1972, Oct.	Cyclone	3	700

Source：CRED-EMDAT



Source：Water resources of TARAWA atoll, Kiribati, 2002

Figure 2-2.4 Annual Rainfall and Water Demand in Tarawa

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources

Annual precipitation in Tarawa is roughly 2,300 mm, however, annual fluctuations are large and the timing of the dry season and rainy season also differs from year to year. Since Kiribati is an atoll island nation composed of small islands, the volume of the freshwater lens (underground freshwater layer) is also small. Accordingly, the country is faced with serious water shortages during dry years.

① Tarawa

Water sources for supply in Tarawa comprise groundwater and rainwater. Under the supervision of the Ministry of Public Works and Utilities, the Public Utilities Board (PUB) conducts the public water supply from wells. In addition to the public water supply, individual households also install rainwater tanks and hand-dig wells.

Locally measured electric conductivity was found to be 14,400 μ S/cm~28,000 μ S/cm in well water, 14.4 μ S/cm~2.8 μ S/cm in rainwater tank water, and 920 μ S/cm~1060 μ S/cm in tap water, indicating high concentrations of salinity. It can thus be concluded that seawater is intruding the well. Rainwater and public water are used for drinking, however, the water from hand-dug wells can only be used for domestic purposes other than drinking. Since salinization is progressing in water from wells near the airport, which are used as the water source for the public water supply, and pumped volumes are inadequate in respect of the population of Tarawa, it is necessary to develop new water sources.

The bridge that connects the districts of Tanaea and Buota is damaged, and the drainage pipe attached to the side of the bridge has been severed, making it impossible to supply public water from the groundwater sources in Buota. Accordingly, out of the two water supply sources in South Tarawa, only the one adjacent to the airport is functional. Accordingly, water supply is partially rationed due to lack of water sources.

Photo 2-2.3 House well in South Tarawa

Photo 2-2.4 Damaged Water Pipe on the Side of the Bridge

② Outer islands

Water sources in the outer islands are rainwater and groundwater. The Gilbert Islands in the north have abundant rainfall and depend on this rainwater. Meanwhile, since rainfall is smaller in the central and southern Gilberts, rainwater and well water are used here, although well water is becoming increasingly saline.

Since there is a lack of ownership regarding the maintenance of water supply facilities (wells) among the local communities, problems exist concerning the maintenance of facilities. Moreover, sufficient funds are not secured to pay for maintenance work.

③ Water resources management organization

The Public Utilities Board operates the public water supply of Tarawa, and it is also scheduled to take responsibility for the operation of the public water supply on Christmas Island.

The Ministry of Public Works and Utilities provides guidance on the construction and operation of regional water supply facilities. It monitors electric conductivity of well water in order to gauge conditions of salinity in the rural communities, however, it is necessary to improve the low level of monitoring technology and inadequate state of communication means.

Concerning the quality of well water, the Ministry of Public Works and Utilities, Ministry of

Public Health and Public Utilities Board conduct water quality measurements without any kind of collaboration or sharing of data.

b) Meteorological observation and disaster prevention

Since almost all the islands of Kiribati are composed of atolls at an altitude of no more than 3~4 m above sea level, they are susceptible to coastal damage caused by high tides, high waves and coastal erosion, etc. Examples of damage caused by high waves can be seen in partial collapse of the Nippon Causeway and the breakwater of the fishing port in Bairiki. As for coastal erosion, it is progressing at Otintaai Hotel seawall, seawall in front of Bikenibeu Primary School, seawall in front of Tungaru Central Hospital and causeways.

① Nippon Causeway

High tides and high waves led to destruction of the revetment in a number of places on the outer sea side near Bairiki in October 2006. The damaged parts have since been repaired and vehicles are able to pass on the causeway.

Wave force acted parapets on the causeway to move, and waves infiltrating cracks between mortar bags loosened the bags. Moreover, scouring around the foundations caused the seawall to move and so on.

② Bairiki fishing port

The upper part of the breakwater has been damaged almost along the entire length. The function of the breakwater is lost and this sometimes means that vessels cannot moor under high tide and waves.

Although the lower part of the breakwater is undamaged, the upper 2~3 m is built from mortar bags. The mortar has become loose and sand is running out from inside. Moreover, this fishing port is the terminal for the route linking South Tarawa and North Tarawa, boarding and alighting from vessels is hazardous when waves are high.

③ Otintaai Hotel seawall

This seawall was built by reclaiming land (by landfill) along the coast. The seawall foundations have been partially damaged, nearby beaches have no sand and the seawall foundations have become exposed.

④ Seawall in front of Bikenibeu Primary School

The seawall in front of the school building that faces onto the ocean has been damaged and washed away in parts.

⑤ Seawall in front of Tungaru Central Hospital

The hospital and part of the coastal road are protected by a seawall on the ocean side, which leave no room for sufficient sand beaches.

According to the survey of erosion conducted by SOPAC in the past, around 5 m of sand beach was lost on average between 1943 and 1998.

⑥ Other erosion

Concerning the causeway linking Nanikai to Bairiki (Nanikai – Bairiki causeway), parts on the south side facing the ocean have been eroded. Moreover, the neighboring radio transmitting station has also become eroded, while part of the antenna radial earth has been washed away. The Ministry of Public Works and Utilities is currently surveying the local area and examining a plan of countermeasures.

On the causeway linking Taborio and Ambo (Taborio – Ambo causeway), parts facing the atoll on the north side have become eroded, and again the Ministry of Public Works and Utilities is surveying the local area and examining a plan of countermeasures.

Coastal erosion is also a problem on the east and north sides of the runway at Bonriki International Airport, and the Ministry of Public Works and Utilities looking at countermeasures.

⑦ Causes of coastal erosion

In addition to natural causes such as high waves and so on, erosion is frequently caused by the construction of coastal structures and extraction of aggregate from coasts and coral reefs, and the same is also true of Kiribati.

According to a survey by SOPAC, up to 100,000 cubic meters of sand and gravel was extracted over five years between 1989 and 1993.

⑧ Meteorological observation

Meteorological observation is currently carried out on four islands (Tarawa, Kanton, Butaritari, Christmas Island). It was previously conducted at eight locations (islands), four observation stations were closed down after equipment broke down and couldn't be repaired. Since the islands of Kiribati are scattered over a wide area stretching from east to west and with differing meteorological conditions, it is necessary to increase the number of observation stations.

In addition to the Meteorological Service, the Ministry of Public Works and Utilities also conducted observations of rainfall, etc., however, many of its observation stations were closed down due to inadequate maintenance of instruments. As a result, data have not been acquired as originally planned. It is necessary for the Meteorological Service and the Ministry of Public Works and Utilities to integrate their observation data and mutually utilize their observation findings.

Observation data from each location are communicated to Tarawa by wireless telephone or satellite telephone. Since this takes a lot of time and effort, a system is required for transmitting and receiving the observation data.

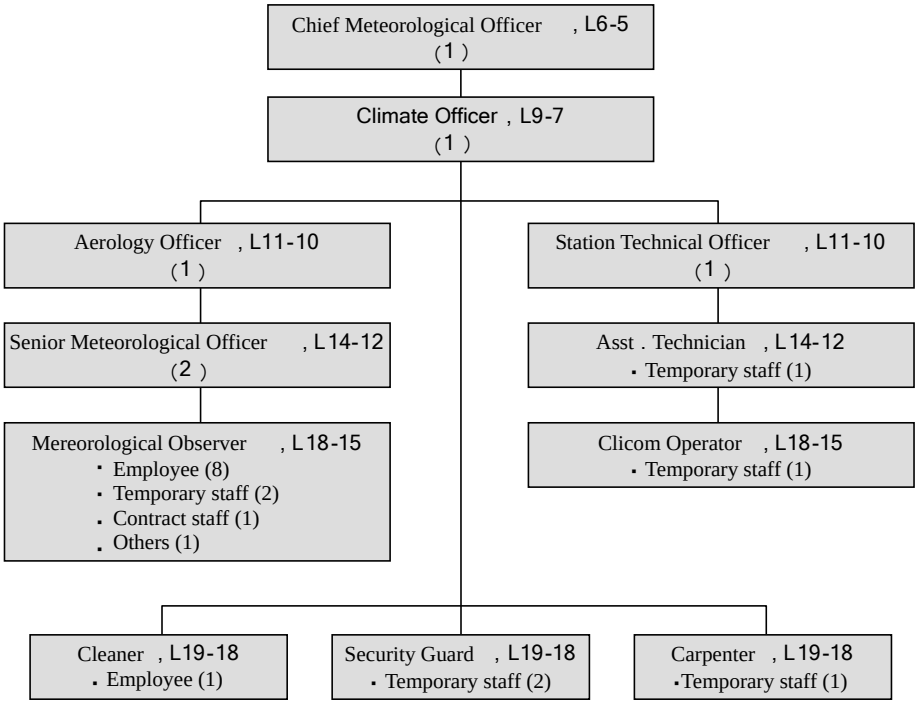
Although meteorological observations are carried out, the data aren't analyzed and the findings are not utilized for making daily weather forecasts or examining weather risks.

Moreover, even if warnings are issued, since islands do not have the means to receive them, evacuation measures and so on cannot be taken.

⑨ Organization in charge of meteorological observation and disaster prevention

The Meteorological Service under the Ministry of Communications, Transport and Tourism Development implements observations concerning climate change. Only five staff, including Chief Meteorological Office, have technology level of climate forecaster. It is desirable to raise capacity of the other staff. Organization chart Kiribati Meteorological Service are shown in Figure 2-2.5.

Moreover, the Ministry of Public Works and Utilities observes rainfall, etc. from the viewpoint of water resources.



Source: Kiribati Meteorological Service

Figure 2-2.5 Organization Chart of Kiribati Meteorological Service

Concerning disaster management, the National Disaster Committee has been organized with the National Disaster Management Office as a subordinate agency. There are also training plans for related personnel.

The Civil Engineering Division of the Ministry of Public Works and Utilities implements coastal erosion countermeasure works. Moreover, the Ministry of Public Works compiles training plans and implements training.

Coastal management affairs pertaining to coastal disaster prevention falls under the jurisdiction of the Ministry of Environment, Land and Agricultural Development, however, according to the assessment of the Kiribati Adaptation Program II (KAP II), it doesn't possess sufficient management capability and no management plans exist. The NAPA cites coastal management as a project, and this includes organizational strengthening.

(b) Future impacts

a) Water resources management

Due to the effects of climate change, droughts are lasting longer and this is hindering the utilization of rainwater. Moreover, since the freshwater lens of Tarawa is small to begin with, if rainfall declines and the groundwater level falls further due to climate change, salinization of well water will progress further and water shortages will become even worse. There is a strong likelihood that similar problems will also arise on outlying islands.

b) Meteorological observation and disaster prevention

High tides and high waves are already causing damage to coastal facilities. If climate change leads to increase of the sea level and higher frequency of high waves, it is predicted that coastal facilities will be destroyed. Concerning coastal erosion, since high tides lead to changes in wave conditions and consequently changes in littoral drift (natural factors), it is likely that fluctuations in erosion and accretion will become more pronounced.

Since population pressures have led to further development of coastal areas and extraction of gravel, these conditions will further exasperate erosion damage caused by the rising sea level and high waves.

2) Government Measures and Cooperation Needs

(a) Government measures

In response to the problems of climate change, the Kiribati government has compiled the Kiribati Adaptation Program (KAP) under direct jurisdiction of the Office of President, while the Ministry of Environment, Land and Agricultural Development, acting as the implementation agency, has compiled the NAPA. Accordingly, government agencies are at the forefront of concerted efforts to deal with the impacts of climate change.

KAP is divided into three phases, and currently the second of these (KAP II) is being implemented. (The originally intended Project period up to 2009 has been extended to December 2010).

Project activities comprise the following five areas: ① Compilation of policies and management of information, ② Physical structures and ecosystems in land use, ③ Sources of freshwater, ④ Development of response capability in outer islands and on the community level, and ⑤ Program management. A budget of As$ 8.7 million has been set aside for the project.

KAP II and NAPA are similar policy documents for implementing climate change countermeasures, however, whereas KAP II is managed by the KAP II Project Department under direct control of the President's Office, NAPA is managed by the Ministry of Environment, Land and Agricultural Development. The President's Office has the right of decision in both programs and there is little difference between the two in this respect.

The contents of NAPA are as follows: ① Water resource adaptation project, ② Simple well improvement, ③ Coastal zone management and resilience enhancement for adaptation, ④ Strengthen environmental, climate change information and monitoring, ⑤ Project management institutional strengthening for NAPA, ⑥ Upgrading of meteorological services, ⑦ Agricultural food crops development, ⑧ Coral reef restoration, monitoring, and stock enhancement, ⑨ Upgrading, restoring, enhancing resilience of coastal defences and causeways, and ⑩ Enabling Kiribati effective participation at regional and international forums o climate change. A budget of As$ 160 million has been appropriated for this project.

a) Water Resources Management

In the Kiribati Development Plan (2008-2011), targets for the water resources sector have been set as the "improvement of lifestyles through improvement of water supply" and "sustainable use of water resources," etc. Work on compiling the National Water Resources Policy and the National Water Implementation Plan was completed in 2008 by the National Water and Sanitation Committee, composed of personnel from government water and sanitation agencies, with support from the Ministry of Public Works and Utilities.

The objectives of this plan are as follows: ① Sustainable and stable supply of safe water in term of society, finance, technology an environment, ② Protection and conservation of freshwater for public water supply, and ③ Effective supply of freshwater. The Ministry of Public Works and Utilities is promoting this based on its own National Water Policy (compiled before the NAPA and KAP II) while also coordinating with NAPA and KAP II where required.

The National Water Resources Policy prescribes the roles of each related government agency and gives the overall direction of programs while dividing targets into short-term targets (~3 years) and medium to long-term targets (4~11 years). Projects are implemented in accordance with this.

The National Water Implementation Plan describes the implementation process for projects proposed under the National Water Resources Policy. It clarifies the order of priority of individual projects and aims to ensure the sure implementation of projects in line with this.

b) Meteorological observation and disaster prevention

The Disaster Management Act and National Disaster Plan have been compiled in the area of disaster countermeasures. As for organization, the National Disaster Committee directly under the President's Office has been established, and provincial governments are also required to set up committees.

Regarding climate change countermeasures, a coastal disaster prevention project is included in KAP II. This contains plans for the prevention of coastal erosion in front of Tungaru Hospital and coastal road erosion countermeasures on the causeway linking Nanikai to Bairiki, Taborio to Ambo, and prevention of erosion on the east side of Bonriki International Airport. However, plans above have not yet been implemented. The Ministry of Public Works and Utilities is conducting surveys on coastal erosion and is planning countermeasures based on the findings.

Basically, in KAP II, projects have been implemented as pilot projects level, and these will be fully deployed in KAP III.

(b) Cooperation needs

Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management

- Conservation of the freshwater lens amidst rising sea level
- Groundwater development in North Tarawa (Buota, Tavitewea, Abatao) and construction of water supply facilities to improve water supply shortage in South Tarawa.
- Improvement of water supply (installation of rainwater tanks, etc.) on outer islands
- Introduction of seawater desalinization plants
- Development and technical capacity building of personnel in charge of water resources management

b) Meteorological observation and disaster prevention

- Installation of meteorological observation stations on outer islands
- Installation of meteorological observation instruments
- Establishment of an observation data communications network
- Capacity building with respect to meteorological observation and forecasting
- Warnings of tornadoes and abnormal tides on remote islands
- Establishment of disaster and disaster prevention radio communications network
- Coastal erosion countermeasures at each radio broadcasting station
- Enhancement of disaster prevention broadcasting capacity
- Coastal erosion countermeasures at Tungaru Central Hospital
- Coastal erosion countermeasures at Bonriki International Airport
- Erosion countermeasures on causeways in Tarawa (Nanikai~Bairiki, Taborio~Ambo)
- Coastal erosion countermeasures on outer islands

2-2-3 Independent State of Papua New Guinea

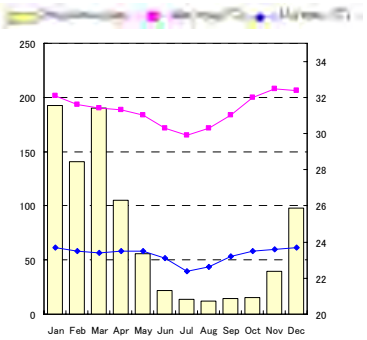
(1) General Condition

1) Population

Papua New Guinea has a total population of approximately 5,900,000, of which approximately 300,000 live in the capital Port Moresby, 2,200,000 live in the coastal areas of New Guinea Island, 2,300,000 live in the highlands, and 1,100,000 live in New Britain and other islands. It is crucial problem that marine environment around marine plant and coral reef is being deteriorated due to the sewerage from Port Moresby with growing population. This problem is considered as important issue for Ministry of Environment.

2) Climate

Apart from the high mountain parts, almost all of Papua New Guinea has tropical climate with monsoon influence. Temperatures are generally the same throughout the year; mean temperature in Port Moresby and the second city of Lae is approximately 27℃ but falls to approximately 18℃ in the highlands. Annual rainfall in Port Morseby is low at around 1,000 mm, and the dry season lasts from April to November. In Lae, on the other hand, rainfall exceeds 4,500 mm per year. Meanwhile, Gulf Province, which faces onto the Gulf of Papua, is one of the rainiest places in the world with annual rainfall in excess of 8,000 mm.



Source：WMO

Figure 2-2.6 Temperature and Rainfall in Port Moresby

3) Geography

Papua New Guinea, situated to the north of Australia, is composed of more than 1,000 islands including the eastern half of New Guinea Island, New Britain Island, New Ireland Island and Bougainville Island, etc. and having a combined area of 462,000km^2. The central part of New Guinea, which contains the capital city Port Moresby, has a mountain range ranging from 3,000 m to 4,500 m in altitude, and the highlands here have deep precipitous valleys. Sepik River, which originates in the mountains close to the border with Indonesia and meanders eastwards for 1,126 km, forms a huge marshland in its middle reaches, Apart from the high mountain areas, land is covered in tropical rainforests and coral reefs are found in island and coastal areas. New Britain Island and other islands are active volcanic islands.

4) Past Major Natural Disasters

Papua New Guinea experiences frequent damage from flooding and landslides. Figure 3 shows the dry weather damage that occurred in 1972, 1987, 1991, 1992, 1993, 1994, 1997 and 2002. The drought of 1997/98 was the most serious and made it necessary to enforce water restrictions. In recent times, dry years occur once every 3-5 years.

Table2-2.2 Past Major Natural Disasters

Date	Classification	Fatalities	People Affected
2005,Feb.	Strong wind		300
Mar.	Flood		10,000
Mar.	Flood		5,000
Mar.	Flood		
Apr.	Flood		5000
Apr.	Land slide		170
Oct.	Eruption	1	9832
2005, Apr	Eruption		2,273
Jul.	King tide		30,730
Oct.	Flood		30,000
Oct.	Eruption		20,000
2006, Jan.	Land slide	13	151
Feb.	Flood		2075
Feb.	Spring tide		4,100
May	Flood		23,148
Jul.	Earthquake		1008
Oct.	Eruption		13,354
Aug.	Flood/Land slide		10, 000
Oct.	Hail		3,000
Nov.	Flood		130,000
Nov.	Flood		2,248
Oct.	Flood		133,000
2008, Jan.	Land slide		2,007
Feb.	Land slide		2,000
Feb.	Flood		561
Feb.	Rising sea level		7,808
Jul.	Volcanic activity		14,622
Jul.	Rising sea level		-

Source: PNG National Disaster Office

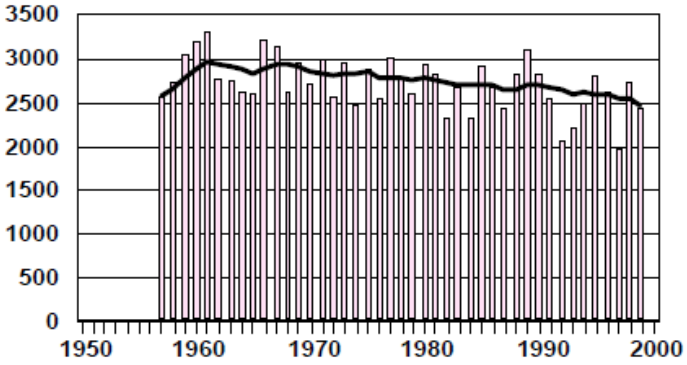


Figure 2-2.7 Annual Rainfall in PNG

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources management

Annual precipitation in Papua New Guinea (PNG), which has a tropical marine climate, varies greatly from 1,200mm to 9,000mm between the coastal lowlands and the mountainous belt in the west. Water resources, which can be used for drinking and living water, exist in the form of rivers and groundwater over the entire country. In coastal areas, however, annual mean precipitation is lower than in the mountain areas at 1,000~1,500mm. The El Nino phenomenon in recent years has caused droughts and nationwide water shortages.

① Low plains and small islands

Salinization is widely occurring in coastal areas of PNG, and many wells have fallen into disuse for this reason. This problem is especially conspicuous in coastal lowlands and small islands in Manus Province, Madan Province, New Ireland Province, North Solomon Province, West New Britain Province and East New Britain Province, however, the real situation regarding salinization has not yet been ascertained in detail by PNG Government.

Salinization is progressing in the northern small islands of Manus and Bougainville, etc. and has reached critical levels in small atoll islands. Moreover, on the remote islands, salinization and droughts aggravate water shortages even more.

The decline in water resources is not only affecting potable water supply in PNG. There is also possibility of irrigation water shortages occurring, and there is concern over the impact these will have on rice cultivation.

The tourism industry is prosperous on and around Manus Island and Lavaul Island. In addition to receiving water from local water supply agencies, the tourist hotels here have

their own private wells and other alternative water resources and are able to cope in cases of emergency.

② Urban areas

Pondage of the multipurpose dam which supplies electricity to the capital Port Moresby has been declining in recent years. In response to this, the amount of generated electricity has been reduced so that water supply can be compensated, however, there are also cases where water rationing has to be implemented.

The El Nino phenomenon has caused droughts in recent years, and there is no collection or analysis of hydrological data with a view to effectively utilizing or developing water resources in future. In addition, even though population and demand for water are rising, new sources for the public water supply are not being developed.

There is a danger that environmental pollution caused by the discharge of sewage will further exasperate the impacts of climate change.

③ Rural areas

Rainwater is frequently used on the home level, however, in regions where the dry season continues for a long time, the water demand cannot be covered by rainwater alone.

④ Water resources management organization

Water supply in the capital Port Moresby is operated by Eda Ranu, and the supply rate is almost 100%. The PNG Water Board of Directors operates the water supply in 13 cities, while local governments operate the water supply in other regional cities. Water supply in village communities is conducted by the local governments, however, there are no data to demonstrate this.

b) Meteorological observation and disaster prevention

Possessing diverse topographical and geological conditions, PNG experiences numerous disasters such as earthquakes, tsunami, drought, flooding, frost, rising sea level, volcanoes and cyclones, etc. Disasters relating to climate change are landslides and flooding caused by torrential rain and coastal erosion, and it will be necessary in future to examine compound disasters, etc. and clarify the cause and effect relationship with climate change.

① Coastal erosion

Due to population increase and coastal erosion, the residential area of migrant has become restricted and there is increasing vulnerability with respect to tsunami and high tides, etc as mentioned below:

In January 2009, increase of the sea level led to the temporary evacuation of residents, however, evacuation was made difficult by the traditional land ownership system and demarcations between tribes.

Photo 2-2.5 Coastal Defense Facilities by Residents (Provided by NDC)

Settlements along the coast in Manus Province are situated 0.5~1.5 m above sea level and are prone to the effects of high tide, coastal erosion and inundation. For example, Amic Island of the same province has high population density with 0.8m land height and 71m^2 of area. Resident of the island put stones along the coastal defense by themselves as measures, but it is not effective. Soft measures (house removal and evacuation) are impossible.

In Lai Village on Lao Island, the cliff line has receded 60~75 cm over the past 40 years. At Ponam Atoll in the north of Manus, the residents have constructed coastal protection facilities(see Photo 2-2.5), however, these comprise walls made from stone masonry and plant leaves and are not very effective. The coastal road

linking Manus Island and Manus Airport Island is at risk of being inundated by high tides. Moreover, when tide water infiltrates lowlands, surface soil and vegetation are removed, sand accumulates and salt water flows in, leading to the contamination of fresh groundwater. As a result, land along the coastline has become abandoned.

Photo 2-2.6 High Tide Damage in Gulf Province (Provided by NDC)

In Gulf Province, approximately 30,000 people suffered damage when high tides caused inundation in July 2005. At this time, natural forests and planted forests along the coast were uprooted by the high tides. Solutions to the problem are being examined, but countermeasures have not progressed so far.

In December 2008, coastal villages on Sinberi Island in New Ireland Province were destroyed by high waves. According to PNG Government, it is possible that tsunami damage has become worse than before due to the destruction of mangrove forests brought about by tree felling and use of dynamite fishing.

On coral islands, the extraction of building aggregate is resulting in acceleration of coastal erosion of the islands, and a similar thing is happening on small islands in the north.

Amic Island in Manus Province has high population density, altitude of 0.8 m and an area of 71 m^2. The residents are attempting to build defenses through piling stones, etc, however, these are not effective. Moreover, it is not possible to implement soft measures such as relocation and evacuation, etc.

Photo 2-2.7 Large-scale Landslide in Kaiapit (Provided by the Geological Survey Office)

② Flood and debris flow

The almost total absence of data concerning flood occurrence in PNG makes it difficult to plan countermeasures. Situation of the representative flood and debris flow is mentioned below.

In a landslide (see Photo 2-2.7) which occurred in Kaiapit in the highland area, two villages were buried and 75 people lost their lives. This flooding resulted in the destruction of the Highland Highway when ground that had been weakened by an earthquake collapsed under torrential rain.

In view of the frequency of landslides triggered by earthquakes, the National Disaster Center is considering a connection with climate change.

In 1996, a natural dam was formed on Boana River in Morobe Province, and a flood containing sediment occurred and caused damage to Busu Bridge (see Photo 2-2.8).

Photo 2-2.8 Bridge Damage Caused by the Boana Flood (Provided by the Geological Survey Office)

On the Biniguni floodplain in Milne Bay Province, inundation damage occurred in the villages of Oro and Kawansesap during cyclone Guva in 2007.

Concerning management of the floodplain, assessment and digitization of the local vulnerability are being carried out.

③ Drought

The highlands have preciously suffered major economic losses due to droughts, and the effects of these have extended to 3,000,000 people.

④ Cyclone

Cyclone Guva caused the destruction of houses in Kawansesap Village in 2007 (see Photo 2-2.9). Since the local buildings have low resistance to high winds, it is necessary to review and implement new building criteria, etc.

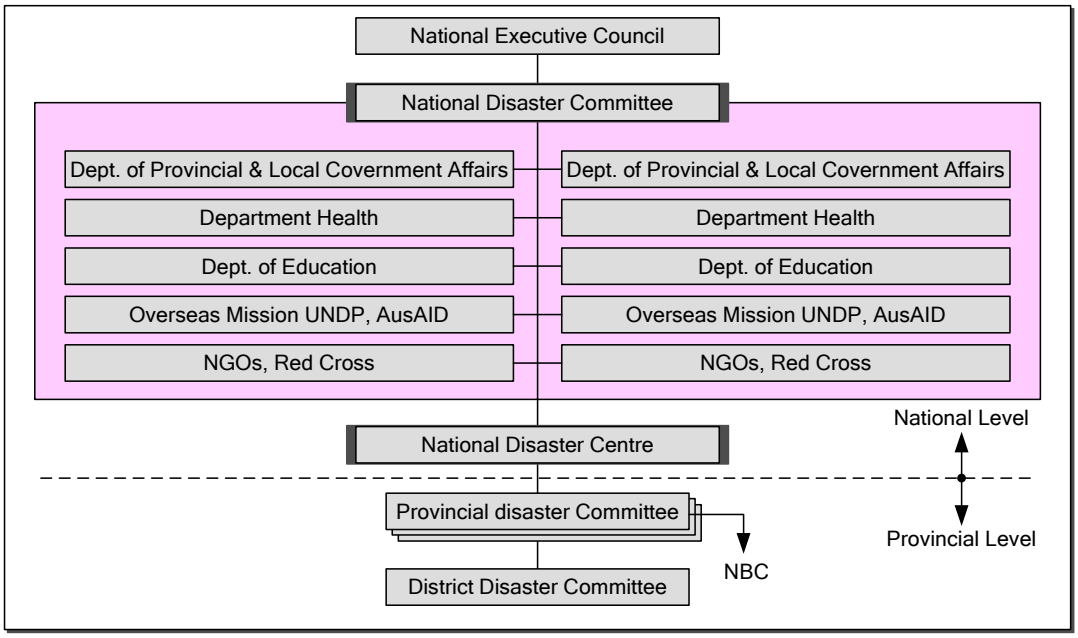
⑤ Impacts on sanitation

Due to the advancement of global warming, relative temperature is also increasing in PNG, and this is leading to concerns over the outbreak of malaria in highland areas.

Photo 2-2.9 Cyclone Damage to Homes (Provided by the NDC)

⑥ Disaster management setup

The supreme decision making authority within the national disaster management setup is the National Disaster Committee, which is composed of seven vice ministers and two donor representatives under the guidance of the National Executive Council. The current situation is inadequate concerning the meteorological observation network and evacuation warning system. National Disaster Management setup is shown in Figure 2-2.8.

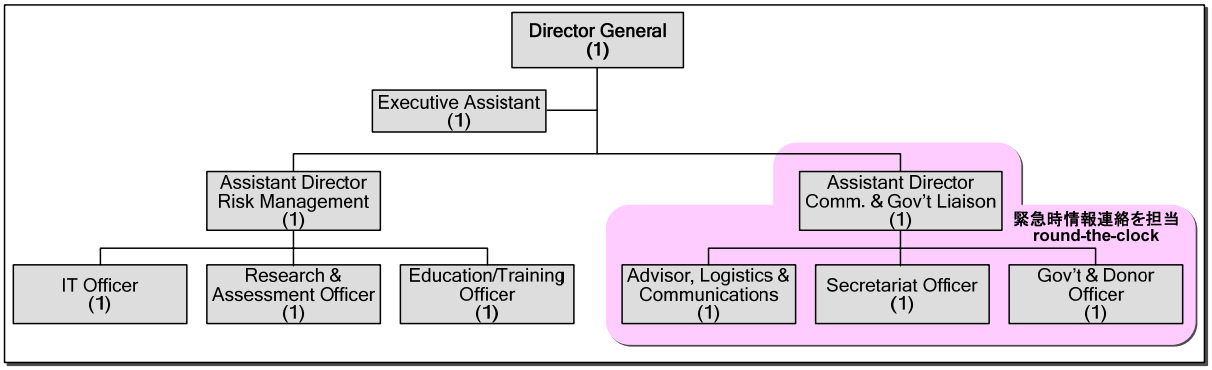


Source: NDC

Figure 2-2.8 National Disaster Management Setup

The National Disaster Center is a subordinate organization of the National Disaster Committee. Moreover, the NDC is linked to Provincial Disaster Centers and District

Disaster Centers on the provincial and district levels. Figure 2-2.8 shows National Disaster Center Organization.



Source: NDC

Figure 2-2.9 National Disaster Center Organization Chart

The NDC is composed of 10 employees headed by the Director General. The Center is operated 24 hours a day from Sunday to Saturday by three employees working under the Assistant Director in charge of communication and government liaison. The Center requested the government to increase personnel a few years ago, however, this request has not yet been granted.

The NDC utilizes a wireless system to communicate with the PDC, DDC and local disaster management committees. This system involves partially borrowing the hospital wireless system (3 wave). Considering the situation in terms of fixed telephones and telecommunications in the country, radio is thought to be the only effective means of communication.

Since this hospital wireless system lacks multicasting performance and stability, etc., problems are sometimes experienced in communications from the NDC to the PDC and DDC.

The meteorological observation network and evacuation alarm system for disasters are not adequately established. Provision of disaster information to citizens is carried out by the National Broadcasting Corporation (NBC). The NBC has branch offices in each province and its personnel are members of PDCs. When PDCs decide to implement disaster broadcasts, a request is issued to the NBC, which implements the broadcast in response.

Disaster broadcasts are conducted by relaying radio short-wave broadcasts to each area via medium wave and FM, however, due to the poor state of local relay stations, broadcasts cannot be simultaneously conducted to all 19 provinces of PNG in real time.

Conventional news coverage by the NBC is conducted between 05:00~24:00, which is the same as radio broadcasting times, however, at times of disasters, a 24-hour setup is adopted.

⑦ Meteorological observation and forecasting

Increase in sea level has been recognized in coastal areas all over PNG, however, there are no data showing changes in sea level over time.

Not every province (19 provinces) has a meteorological observation station: there are 14 observatories in 13 provinces. Highland areas in particular do not have observation facilities, so it is not possible to gauge weather conditions in inland areas centering on the highlands.

The Meteorological Service overall has 66 employees, however, the government is currently discussing plans to increase this number to 147. Out of the 66 present staff, seven are in charge of climate change. Moreover, only three staff members are at Level 1, which is the level required by the World Meteorological Organization (WMO) for weather forecasters. Budget limitations have led to the training center being closed and the training of weather forecasters being impeded.

Weather observations are carried out every hour for 14 hours between 05:00 and 19:00. However, the airport observatory in Port Moresby operates for 24 hours a day.

Data transmission from regional meteorological observation stations to the Observation Center in Port Moresby is sometimes interrupted due to the poor telecommunications. As a result, aggregated observation data are frequently incomplete.

The maintenance room construction plan, which is geared to implementing maintenance of observation instruments, remains unfinished (part of the building is completed) due to budget delays from the government.

(b) Future Impacts

a) Water resources management

According to the PNG National Research Institute, due to the impact of climate change, it is predicted that salinization of groundwater will grow worse in almost all coastal areas while the effects of drought will worsen in mountainous parts on the main island of PNG.

Water supply in the capital Port Moresby, provincial towns and district towns is obtained from river water and groundwater, and the adverse effects of drought (droughts) will be especially serious for water supply derived from rivers.

b) Meteorological observation and disaster prevention

Unless meteorological observation is carried out on an ongoing basis and actual meteorological conditions are understood by residents, it is difficult for the Government to examine countermeasures and inform the residents, thereby raising vulnerability to disasters. Due to the effects of rising sea level, high tides and high waves, residents in coastal areas will become increasingly prone to damage, and the scale of damage will also increase. If precipitation increases due to climate change, damage will increasingly occur in and around river floodplains, which are already vulnerable, as well as roads and bridges subject to sediment damage in mountain areas.

c) Impact on tourism

The tourism industry is prosperous in Madang, Ravaul and Arotau, etc. Hotels secure their own alternative sources for drinking water and so on. Accordingly, in the future event where climate change causes unexpectedly large disasters imparting damage to the facilities of each hotel, restoration work will be left to each hotel and it is possible that delays will occur in the regional recovery effort.

When it comes to implementing various disaster management measures in future, the type of protection measures adopted will determine whether or not the impact can be mitigated on tourism, which is an important source of foreign currency.

There is also a strong possibility that increasing frequency of disasters will deter tourists from visiting PNG. Changes in marine ecosystems such as coral reefs and mangrove forests, etc. brought about by environmental pollution will in the long run have a major negative impact on the tourist industry. It will be necessary to disclose more disaster information and prepare an environment whereby tourists can feel safe about visiting PNG.

2) Government Measures and Cooperation Needs

(a) Government measures

Climate change countermeasures are regarded as an important prerequisite for sustainable development within the Medium Term Development Strategy (2005-2010), however, initiatives against climate change have not been incorporated as a major component within existing development plans.

Although PNG has not compiled a NAPA, it has established a Office of Climate Change and Environmental Sustainability directly under the Prime Minister’s Office, and a government-wide setup for responding to climate change has been prepared. Also, a budget of 3,000,000 kina has been secured for the formulation of a strategy. The main activities in this are adaptation and mitigation measures and capacity development.

Concerning the relationship between the Office of Climate Change and Environmental Sustainability and the Ministry of Environment and Conservation, which has conventionally been responsible for environmental policy, the former organization is in charge of administration associated with climate change, while the ministry is responsible for other environmental administration. However, the detailed division of duties has not yet been specified and it will be necessary to clarify this in future.

a) Water resources management

The Ministry of Environmental Conservation implements water quality monitoring for the purpose of water resources management, and it strives to promote safe water supply. As for water supply implementing organizations, the Eda Ranu operates in Port Moresby, and the PNG Water Board operates in provincial cities.

b) Meteorological observation and disaster prevention

Concerning disaster countermeasures and mitigation policies, a natural disaster setup and Natural Disaster Act have been compiled, and the National Disaster Center implements climate change countermeasures in accordance with these.

The Ministry of Public Works and Utilities conducts assessment of facilities and flood mitigation works with a view to preventing road damage by flooding.

The National Broadcasting Corporation is in charge of damage information to residents and is examining ways to improve related equipment.

(b) Cooperation needs

Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management

- Fact-finding study of salinization in coastal areas
- Study geared to selecting alternative water resources
- Construction of a nationwide hydrological observation network
- Establishment of sustainable water systems for coastal communities

b) Meteorological observation and disaster prevention

- Installation of river flow observation posts
- Support for implementation of compiling hazard map, topographical surveying, digitization and vulnerability assessment
- Training and acquisition of technology, in particular concerning geographical information system (GIS) and disaster management
- Installation of sophisticated GIS equipment in the University of Papua New Guinea (for use in the climate change and disaster risk management program for bachelor and master students)
- Training of engineers skilled in coastal adaptation and mitigation measures in atoll islands and other small remote islands
- Financial support for soft adaptation measures or green belt (mangrove forestation, etc.) adaptation measures
- Construction of the meteorological observation network
- Installation of early warning equipments

2-2-4 Republic of Vanuatu

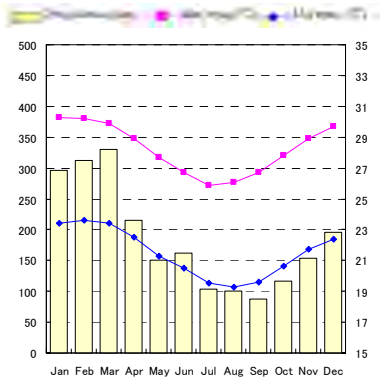
(1) General Condition

1) Population

Vanuatu has a population of approximately 220,000, of which approximately 70% live on Efate Island, Espiritu Santo Island, Malakula Islanda and Tanna Island. The largest city is Port Vila on Efate, and the second largest is Luganville on Espiritu Santo. Deterioration of coastal environment is becoming obvious in recent population increase.

2) Climate

Vanuatu has subtropical climate in the south and tropical climate in the north. The rainy season is characterized by high temperatures and high humidity, while the dry season has extended dry and clear spells. Annual rainfall exceeds 4,000 mm on the islands that belong to the tropical climate zone. The capital Port Vila has a maximum temperature of 29℃ in rainy season and this drops to around 25℃ in the dry season. Annual rainfall in the capital is 2,300 mm with most rain falling between January and April, while August has the lowest rainfall of around 80 mm. Cyclones occurs in rainy season.



Source: WMO

Figure 2-2.10 Temperature and Rainfall in Port Vila

3) Geography

Vanuatu is composed of 13 larger islands and about 70 smaller ones stretching approximately 1,200 km from north to south and covering a land area of approximately 12,000 km2. The largest island is Espiritu Santo (3,947 km^2), and Mt. Tabwemanasana on this island is the highest peak in the country at 1,878 m. Efate Island, which contains the capital city Port Vila, is the third largest island with an area of approximately 980 km^2. Roughly half the islands that make up Vanuatu are volcanic islands with extreme undulations, and they are largely covered in thick forests. The remaining islands are coral islands.

4) Past Major natural Disasters

Vanuatu experiences damage from cyclones, volcanic eruptions and earthquakes almost every year. Figure 3 shows changes in annual rainfall in Luganville. Between 1960 and 2006, annual rainfall decreased by an average of 25.3 mm/year. Moreover, a drought (approximately 600 mm of annual rainfall) occurred in 1982. Fluctuations in annual rainfall have been large from 1980 onwards, and there are increasing concerns over damage from both dry weather and torrential rains. Trend of sea level fluctuation in Capital city Port Vila is shown in Figure-2-2.12. Sea level is rising 5.5mm/year in average since 1993-2007. Salinization of groundwater in coastal aquifer is noticed.

Table 2-2.3 Past Major Natural Disasters

Date	Classification	Fatalities	People Affected
2006, May	Eruption		
2005, Nov.	Eruption		5,000
2004, Feb.	Cyclone	2	54,008
2002, Dec.	Earthquake		3,001
Nov.	Earthquake		503
Jan.	Eruption		500
2001, Jun	Flood		4,500
Apr.	Cyclone	1	800
Feb.	Cyclone	1	

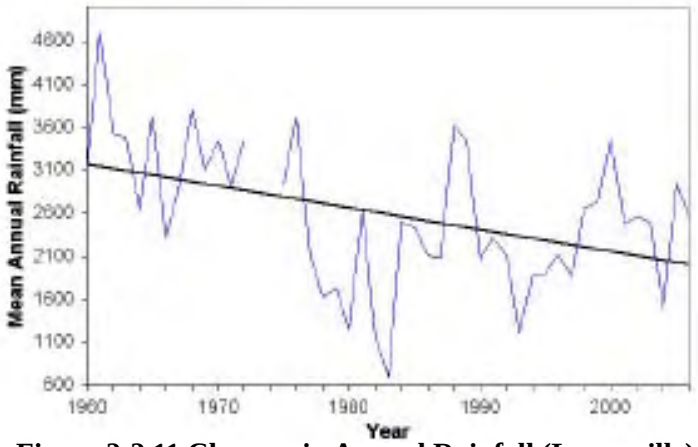


Figure 2-2.11 Changes in Annual Rainfall (Luganville)

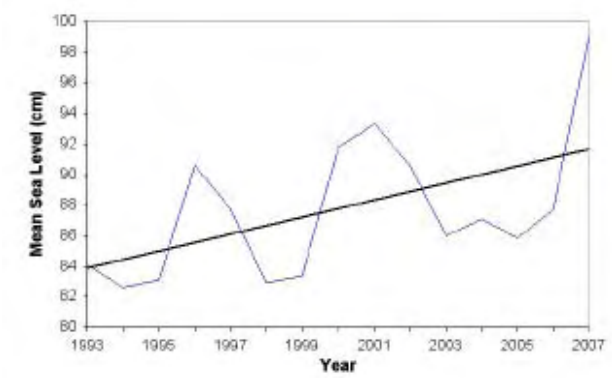


Figure 2-2.12 Trend of sea level fluctuation (Port Vila)

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources management

Most of the islands of Vanuatu including the main island of Efate are volcanic. On the larger islands, since groundwater, spring water, rainwater and river water can be used as water sources, water resources are relatively plentiful. However, due to the small scale of water supply facilities, water shortages occur during droughts. Meanwhile, on the smaller islands, since only groundwater and rainwater can be used for water supply, water shortages during droughts are serious. Moreover, the salinization of groundwater is progressing. The following paragraphs describe the vulnerability experienced by urban areas and provincial areas in Vanuatu.

① Urban areas: The capital Port Vila (Efate) and Luganville (Espiritu Santo)

In Port Vila (population approximately 40,000), a private sector company operates the water supply. River water is used as the water source, however, due to concerns over pollution caused by domestic wastewater in recent years, the water source has been switched from Tagame River to Teouma River. The quality of water has been improved as a result, however, since the water supply is dependent on river flow, there is still danger of water shortages occurring in the event of extended drought.

In Luganville (population approximately 12,000), the Public Works Department (PWD) operates the water supply. Water is obtained from spring water at the base of mountains, however, at times of torrential rain, domestic wastewater infiltrates wells and contaminates the groundwater. Moreover, due to the extreme deterioration of distribution reservoirs and distribution pipes, water supply troubles occur frequently. Since fluctuations in spring water volume are large and water shortages occur during droughts, plans are being considered to develop new wells.

Luganville Public Works Department does not have the capacity in terms of both manpower (only five employees) and management ability to immediately respond to emergencies (water shortages, water accidents and damage to facilities). Moreover, because it possesses hardly any water management instruments and water quality management personnel (only one member), the situation regarding the quality management of water supply is also problematic.

② Provincial areas

Village communities operate and maintain water supply facilities under guidance from the Water Resources Management Department, however, due to technical deficiencies and lack of funds, they are unable to conduct sufficient maintenance. Many problems exist in terms of water quality concerning the water supply in rural areas. Wells in coastal areas are prone to the effects of salinization; indeed salinization of groundwater has already been reported on Tegua Island (Torba district), Parma (Malanpa district) and Tongoa Island (Shefea district), etc.

On Ambrym Island, rainwater was previously the main source of water, however, due to the effects of volcanic eruption (volcanic ash and gases), rainwater has become contaminated and it

has become difficult to secure potable water. Accordingly, there is an urgent need to secure alternative sources of water. However, data for alternative sources is not enough. To begin with, it is most important to know water demand and water supply of the area.

On small outlying islands, rainwater and groundwater are the water sources, however, salinization of well water progresses during the dry season, and the rising sea level has aggravated this problem even more in recent years. Furthermore, in addition to the lack of rain during the dry season, the contamination of rainwater resulting from volcanic eruptions has made the water shortages even more critical. Since water sources are smaller on the small outlying islands, water shortages during the dry season are more serious than on the main island.

Photo 2-2.10
Eruption of Ambrym Islands Mt Benbow (17th March)

Source：SOPAC

Figure 2-2.13 West Ambrym Drinking Water pH Measurement

b) Meteorological observation and disaster prevention

① Pre-existing disasters

Vanuatu is situated in the South Pacific cyclone belt (where a cyclone occurs frequently) and cyclones hit the country during the rainy season from November to April. At these times, the cyclone causes flooding and high tides and mudflows. In the past, extremely major cyclones of category 5, 20-30 years probability of occurrence, often hit Vanuatu. Major cyclones to have hit Vanuatu in recent years have been cyclone Uma in 1987 (resulting in 48 fatalities, damage afecting 48,000 people, and costs worth US$50 million) and cyclone Ivy in 2004 (resulting in one fatality, damage affecting 54,000 people, and costs worth US$25 million). Moreover, since Vanuatu is a volcanic nation, volcanic deposits on mountainsides often turn into debris flow that causes damage to communities at times of torrential rain.

Due to the natural population increase and migration from volcanic islands, the population has been increasing in areas around rivers and coastal parts in recent years. Accordingly, there is a growing risk from flooding and high tides when cyclones hit and torrential rains fall. Flooding mainly occurs in the central areas of islands that possess large rivers, for example, Malakula, Espiritu Santo, Efate and Tanna, and such flooding leads to damage and sanitary problems in residential areas.

② Meteorological observation and disaster prevention organizations

The Meteorological Service receives information on clones from the Fiji Meteorological Service, satellite photographs of clouds from Fiji Meteorological Department and Australia Meteorological Department, and tsunami information from Pacific Tsunami Warning Center (PTWC) in Hawaii. The Meteorological Service then reports this information to NDMO and the media. There are seven meteorological observation stations within the department throughout the country and each one has two or three staff

Photo 2-2.11
Transmitter/Receiver at an Observation Center

members, and observation data is sent from each observatory to the Meteorological Service every three hours.

The National Disaster Management Office (NDMO), which is responsible for disaster administration, became independent from the police agency in 2007 and is now an organization directly under the Ministry of Internal Affairs. Since it only has three personnel, i.e. Office Director, Deputy Director and training/education manager, and not enough manpower, it has trouble conducting emergency response to disasters and monitoring, etc. Moreover, since staffs are absent for weeks at a time when they go overseas for training courses, problems exist concerning leadership and guidance when emergencies occur. The National Emergency Management Center, which will be established when disasters occur, is scheduled to be located in the new offices of the NDMO.

Moreover, in Vanuatu, concerning climate change problems, measures are implemented based on the Meteorological Service, and the Director of the Meteorological Service is the chairperson of the National Committee of Climate Change.

The followings discoveries were made as a result of the field surveys and hearings.

③ Urban drainage

Inundation caused by poor drainage is occurring every year in the districts of Fresh Wota, Anambrou, 7-Star and Manplet in the capital Port Moresby, and Solway and Pepsi in Luganville of Espiritu Santo. Some residents pile up sandbags and build simple concrete walls, etc. in order to stop water from flowing into their homes. Meanwhile, the Ministry of Public Works is constructing drainage pits in sports fields in order to accelerate the underground percolation of flood waters (see Photo 2-2.12).

Photo 2-2.12 National Disaster Management Agency Under Construction

④ River flooding

Inundation is conspicuous in low-lying land along Mere River in and around the capital Pot Vila. Meanwhile, since numerous causeways have been constructed along the arterial road that circles Efate Island and these become inundated for two or three hours after flash flooding, transport interruptions are hindering the lifestyles of residents. Similarly, causeway inundation and damage have been confirmed around rivers in the south of Espiritu Santo Island (Navak, Ola, Rapa, etc.).

⑤ Coastal erosion

On Torres Islands, Espiritu Santo Island, Ambae Island, Epi Island and Tongoa Island, erosion is developing into an urgent issue on airport roads and in residential areas. Around San Michel Church in Luganville on the largest island of Espiritu Santo, coastal cliffs have become eroded in a notch pattern and the coastline has receded by around 3 m over the past 10 years (according to a district government employee). The erosion has almost advanced as far as the trunk road. Erosion is also slowly progressing on lowland around the east coast of Efate Island where resort facilities are located.

(b) Future Impacts

a) Water resources management

The future impacts on water resources management are as follows.

- It is forecast that torrential rain will occur more frequently in Luganville, and the risk of contamination of water sources by inundation of domestic wastewater will grow.
- In provincial areas, is forecast that torrential rain will occur more frequently and risk of contamination to community water sources that are difficult to manage will increase.
- The trend of groundwater salinization in line with increase in sea level will increase in small outlying islands (low altitude islands).

b) Meteorological observation and disaster prevention

Since it is predicted that climate change will lead to more intense rainfall over the short term, in Port Vila, where road drainage facilities are not functioning sufficiently, there is concern that flash flood damage will become a regular occurrence, coastal roads and causeways will become inundated and traffic will be interrupted.

In the island groups and Efate Island, which are already affected by coastal erosion, if sea level continues to rise and high waves occur more frequently during atmospheric depressions and cyclones as a result of climate change, erosion will advance even further, and there are fears that infrastructure facilities (roads and bridges) in coastal lowlands around Port Vila will be destroyed and commercial facilities and living areas will suffer increased inundation.

The path taken by cyclone currently shows no major signs of changing, and Vanuatu is likely to continue suffering from cyclone damage in the future. A recent trend is that short-term rainfall intensity is increasing. Since the existing observation equipment cannot measure rainfall intensity, it is difficult to issue early warnings.

c) Impacts on tourism

Surrounded by transparent and beautiful seas and blessed with abundant nature and active volcanoes, Vanuatu devotes a lot of energy to promoting the tourism industry; indeed, tourism accounts for approximately 40% of the GDP (2005). The number of tourists visiting Vanuatu has increased 1.33 times over the past three years (from 68,000 in 2006 to 89,000 in 2008, according to the Statistics Office), and trends in the tourism industry are important economic factors for Vanuatu.

However, since tourism is directly vulnerable to the impacts of climate change, it is necessary to build a sustainable industry through constructing and transferring infrastructure facilities, installing additional water supply systems, compiling hazard maps and conducting risk analysis, etc. as measures to counter coastal erosion and flooding. Tourists are currently concentrated in the two major cities of Port Vila on Efate Island and Luganville on Espiritu Santo Island, however, since it is forecast that tourists will visit provincial cities more in future, it is necessary to compile long-term measures that will enable tourists to safely travel around provincial areas.

2) Government Measures and Cooperation Needs

(a) Government measures

The National Action Committee on Climate Change (NACCC) was established in the latter part of the 1990s and is the central government agency for dealing with climate change issues. The NACCC is currently headed by the Director of the Meteorological Service. The priority NAPA fields that have been so far disclosed are as follows: ① Agriculture and food, ② Water resources management, ③ Forest management, ④ Community-based marine resources management, ⑤ Infrastructure construction, ⑥ Livestock management, and ⑦ Tourism.

a) Water resources management

Government measures in the area of water resources management are as follows:

- Since past countermeasures have comprised only temporary plans and guidelines and have failed to realize the effective utilization of water resources, the government is hurrying to formulate the Integrated Water Resources Management Plan (IWRM) 2008-2018.
- In order to deal with contamination by domestic wastewater, population increase and deterioration of facilities, the government is planning to renew and extend water supply facilities in Luganville.

b) Meteorological observation and disaster prevention

The Government has implemented as the following measures for meteorological and disaster management.

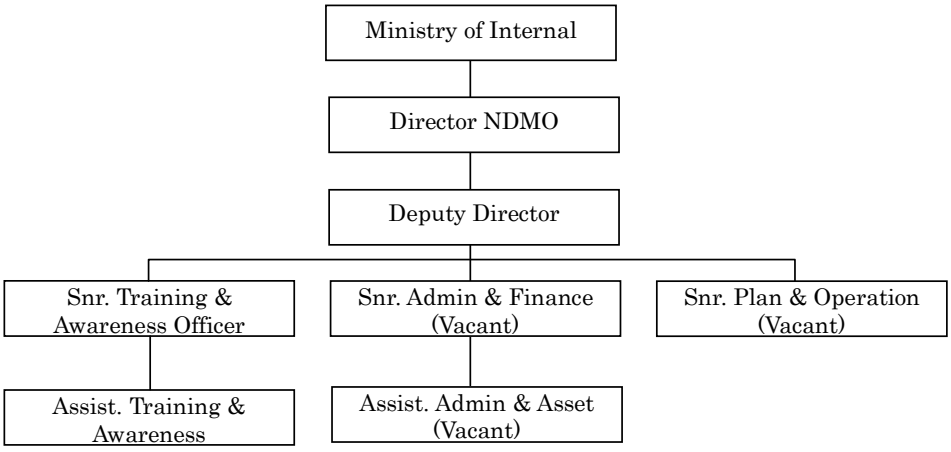
- The Vanuatu Disaster Risk Reduction and Disaster Management National Action Plan 2006-2016 has been established. This contains the following eight priority topics: ①

Strengthening of governance, ② Incorporation into national plans and budget in the disaster countermeasures field, ③ Vitalization of disaster countermeasure activities, ④ Strengthening of disaster management, ⑤ Strengthening of the information transmission system, ⑥ Human resources development, ⑦ Establishment of monitoring and assessment techniques, and ⑧ Strategy for bolstering NAPA implementation capacity. Specific steps are specified in order of priority for each topic: for example, concerning ⑤ Strengthening of the information transmission system, the construction of a real time information transmission system, construction of a data collection method and preparation of hazard maps, etc. are recommended as items for immediate implementation.

- The Integrated Coastal Zone Management Programmes have been compiled and cover the formulation of plans for coastal conservation based on planting of mangroves and vegetation.
- The Second National Communication has been underway since June 2006, and under this areas of vulnerability are being identified and an inventory of greenhouse gases is being compiled.
- As part of the countermeasures to deal with coastal erosion, a project to relocate residents from lowland areas to higher ground has been implemented on Tegua and Tangoa islands under support from CIDA.

The Meteorological Service is composed of the General Affairs Department, Forecasting Department (7 members), Meteorology Department (8 members), Climate Change Department (1 member), Observation Department and Information Technology Department, and it conducts work based on a 24-hour setup. New offices are currently under construction, and these will contain not only the Meteorological Service but also NDMO and the Department of Geology, Mines and Water Resources. The budget for fiscal 2008 is 3,000,000 Vatu including the budget for construction of the new offices. Records concerning rise in sea level are taken by tide gauges at Port Vila and Luganville.

The National Disaster Management Office, which receives guidance from the National Disaster Council, currently has three employees with another two members expected to be added soon. The NDMO receives cyclone information from the Meteorological Service and passes it on to government agencies and the media. It uses short-wave radio (HF) to communicate information to provincial offices, however, this system is currently not working. Radio broadcasts are usually conducted between 06:00 and 23:00, although 24-hour broadcasts are provided when cyclones hit. In the northern province of Torba, two or three employees have visited the local area to conduct workshops on natural disasters and climate change following requests by the local schools, churches and communities. The NDMO also prepares pamphlets and posters, however, its annual budget of approximately 5,000,000 Vatu per year is not sufficient.



Source: Learned from hearings

Figure 2-2.14 National Disaster Management Office Organization Chart

In line with the National Disaster Prevention Action Plan that was adopted in 2006, a Curriculum Task Force was appointed by the Prime Minister in order to revamp the contents of textbooks as one of the strategies in the education sector. A workshop was held in November 2007 under the title of Virtual University for Small States in Commonwealth.

Hazard maps have been prepared with assistance from France, however, these do not apply to flooding, cyclones and high tide disasters.

The NAPA has been compiled under support from SOPAC, WB and UNDP, etc. and items in this include the strengthening of governance, disaster mitigation and management, bolstering of national plans and budget, strengthening of community disaster prevention and so on. Cyclone response plans are prepared in line with this and are renewed every year.

(b) Cooperation needs

Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management

- Measures to deal with urgent water shortages over all areas of Vanuatu and to aid areas where natural disasters have rendered rainwater undrinkable: development of new water sources in the capital Port Vila, construction of additional distribution reservoirs, provision of water tank trucks, portable seawater desalinization apparatus, and vessels for the rapid transfer of water
- Development of new water sources, construction and rehabilitation of distribution reservoirs and pipes, enhancement of water quality management capacity in Luganville
- Water resources volume assessment, water quality assessment and water supply and demand survey on the national scale
- Development of alternative water sources and urgent transport of water by boats in areas where natural disasters have rendered rainwater undrinkable

b) Meteorological observation and disaster prevention

- Strengthening of functions of the National Disaster Management Office
- Improvement of disaster broadcasting capability
- Preparation of integrated hazard maps
- Support programs for dissemination and enlightenment activities
- Expansion of meteorological observation facilities
- Disaster countermeasures utilizing satellite image analysis
- Installation of early warning system for responding to flooding
- Improvement of urban drainage functions in the capital Port Vila and Luganville
- Flood countermeasures on Mere River
- Coastal erosion countermeasures
- Disaster prevention measures on coastal national roads and bridges

2-2-5 Independent State of Samoa

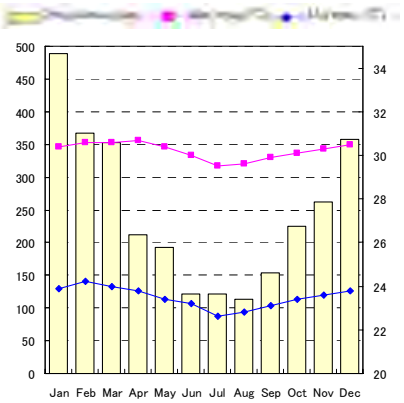
(1) General Conditon

1) Population

The population of Samoa is approximately 185,000. Most of country is occupied by mountain and residential area is limited in the coastal area. It results in population concentration in the coastal area zone. People concentrates in Capital Apia with of population of four thousand, where residential area was expanded newly reclaiming land from swamp-land and also expanded on the slope of the hills, which makes residential area more vulnerable to natural disaster.

2) Climate

Daily temperature in Samoa ranges between 21～30℃; Average maximum and minimum average monthly temperature has fluctuation within 1 ℃ in Capital Apia. The dry season lasts from May to October, and the rainy season is from November to April. The heaviest rain falls from December to February, and rainfall in January is just less than 500 mm. Since 1890, amount of annual rainfall has shown more fluctuation, from 2,000 to 4,000mm in rainy year. Such a trend is strengthened in recent years.



Source：WMO

Figure 2-2.15 Temperature and Rainfall in Apia

3) Geography

Samoa is composed of the two main islands of Upolu, which contains the capital Apia, and Savai'i, as well as their smaller surrounding islands, and the combined land area is 2,840km^2. Samoa's exclusive economic zone covers 120,000 km^2, which is the smallest in the South Pacific region. Upolu and Savai'i islands are both volcanic islands, and Savai'i has Samoa's highest peak of Mt. Silisili (1,858 m).

4) Past Major Natural Disasters

Natural disasters are relatively rare in Samoa, although cyclone damage happens once or twice every 10 years. Figure 2 shows changes in annual rainfall in Apia between 1890 and 2005. Annual rainfall dropped by approximately 50 mm over this period. Dry years are occurring with greater frequency in recent times.

Table 2-2.4 Past Major Natural Disasters

Date	Classification	Fatalities	People Affected
2005,Feb.	Cyclone	9	
2004, Jan.	Cyclone	1	
2001, Apr.	Debris avalanche		
1991, Dec.	Cyclone	13	88,000
1990, Feb.	Cyclone	8	195,000
1989, Jan.	Cyclone		
1968, Feb.	Cyclone		4
1966, Jan.	Cyclone	10	95,000

Source：CRED-EMDAT

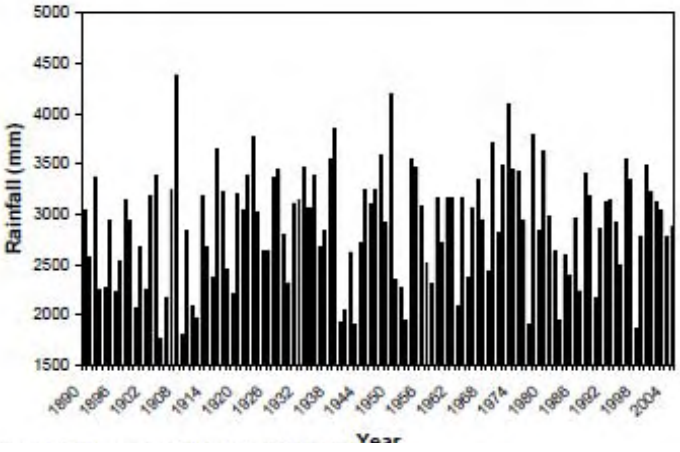


Figure 2-2.16 Changes in Annual Rainfall (Apia)

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources management

The Samoan islands of Upolu (main island) and Savai'i are large volcanic islands possessing usable river water, spring water, groundwater and rainwater. However, torrential rains during the rainy season cause flood damage to water source facilities. On the other hand, during the

dry season, water shortages arise, while the salinization of wells is proceeding in coastal areas. The following paragraphs describe the vulnerability experienced by urban areas and provincial areas in Samoa.

① Urban areas: The capital Apia

Samoa Water Authority carries out water supply in Apia (with a supply population of approximately 40,000 and supply rate of at least 95%). Water is obtained from three springs and undergoes treatment before entering the public water supply. Turbidity of the spring water increases when heavy rains fall. Due to the low treatment capacity of the water treatment facilities, the treatment volume is decreasing and water shortages are occurring. Moreover, due to the small volume of distribution reservoirs, contingency plans for dealing with turbid water and other emergencies are inadequate.

Because the spring water resources in Apia are strongly affected by rainfall, they are subject to large fluctuations in volume and quality. In recent years, annual fluctuations in rainfall have increased, leading to the frequent occurrence of extreme dry spells and torrential rains, and the impact on water resources has increased accordingly. As a result, water shortages during dry years and flood damage during rainy years have become more frequent.

Samoa Water Authority has inadequate emergency response capacity in terms of the number of employees and its management capacity. It also faces problems in terms of water quality management due to its lack of equipment and manpower.

② Upolu Island rural areas, and Savai’ Island

Water supply in rural areas is obtained from groundwater, spring water and rainwater, and is provided to residents through supply facilities managed by the local communities. Since salinization of groundwater is advancing in coastal areas, groundwater tends to be used for living purposes other than drinking, while rainwater is used as potable water. During dry spells, water shortages arise because groundwater salinization becomes even more pronounced and rainwater is not available. The rising sea level is further accelerating the salinization.

In cases where spring water is used to provide rural water supply, the spring water becomes turbid and infiltration of domestic wastewater to supply facilities causes contamination at times of torrential rainfall during the rainy season. At such times, the capacity of facilities becomes restricted and water shortages occur.

b) Meteorological observation and disaster prevention

Samoa is composed of the two main volcanic islands of Upolu and Savai’ i in the middle of the South Pacific Ocean. The islands are vulnerable to natural disasters such as cyclones and high tides caused by cyclones. Since many of the population live in coastal areas, it is forecast that damage from natural disasters will become even larger, and the implementation of urgent disaster countermeasures has become an urgent issue. Between 1950 and 2004, Samoa experience extreme cyclone and flood disasters in 12 occasions. For example, in 1990, cyclone Ofa caused eight fatalities, damage to approximately 170,000 citizens and costs worth up to US$140 million, while in 1991, cyclone Val caused US$300 million of damages. In 2004, coastal areas, seawall facilities and major crops suffered extensive and critical damage.

The following paragraphs describe vulnerability in the fields of meteorological observation and disaster prevention.

① Urban drainage

Urbanization of the capital city Apia has progressed rapidly due to the development of tourism and concentration of population, however, due to land-filling, blockage of drainage channels and the fact that drainage was not incorporated into the city plans, inundation and flooding regularly occur at times of torrential rainfall. Moreover, due to inadequate land use regulations and guidelines, channels have become filled with sediment and are badly maintained, and the resulting poor drainage leads to flooding every year. Currently, outfall channels and drainage channels are undergoing rehabilitation and repair on the lowland flood plains of Gasegase River and Asaga River in just a part of the city.

② River flooding

Because rivers in Samoa have small catchment areas and rapid flows, flash floods commonly occur during cyclones and torrential rainfall. Torrential rains in April 2001 caused Vaisigano River (catchment area = 34 m^2, channel length = 12 km, river gradient = 7%) in Apia to flood its banks and cause damage affecting 5,000 people and costing ST$11 million. Inundation area by above flood covered wide area as shown in Figure 2-2.15. Flash flooding again caused major damage in 2006.

Figure 2-2.17
Flooded Area and Direction of Flood Flow in the Flooding of 2001

Source: SOPAC

Photo 2-2.13 Flash Flood of 2006

③ Coastal erosion

Erosion is advancing in the district of Sorosoro along the eastern coastal road, and the area becomes inundated when cyclones approach. Also, the western coastal road leading to Foleo Airport becomes partially inundated at times of high tide and strong winds.

④ High tide, etc.

The coastal seawall at Apia has already been constructed, however, road inundation caused by high waves at times of wind and rain is conspicuous, and the Meteorological Agency observation facilities yard at Cape Murinuu is also prone to high waves.

⑤ Disaster countermeasures

The Disaster Management Office under the Meteorology Division of the Ministry of Natural Resources and Environment is primarily responsible for disaster countermeasures. It is currently staffed by three members, and its warning and relief activities are hindered by lack of budget and manpower. The current evacuation system is built around the tsunami disaster network, and evacuation training based on tsunami warnings is carried out two times per year. However, evacuation training for cyclones is not implemented. Relief activities at times of disasters are mainly implemented by the National Disaster Committee, NGOs, churches and the Red Cross.

⑥ Meteorological observation

In order to mitigate the effects of damage caused by cyclones and flooding, it is necessary to conduct wide area forecasting of cyclone routes as well as localized forecasting of rainfall. Wide area forecasting is carried out based on information received from the Fiji meteorological agency. At the existing meteorological observation points (apart from the Meteorological Agency headquarters and airport), since employees measure only basic data using instrument screens and rain gauges once per day, it is difficult to implement pertinent and localized countermeasures at times of natural disaster risk.

(b) Future Impacts

a) Water resources management

The future impacts on water resources management are as follows.

- In Apia, when torrential rain falls, increased turbidity of raw water will accelerate the blockage of slow filter basins and increase the amount of time that stable water supply cannot be conducted.

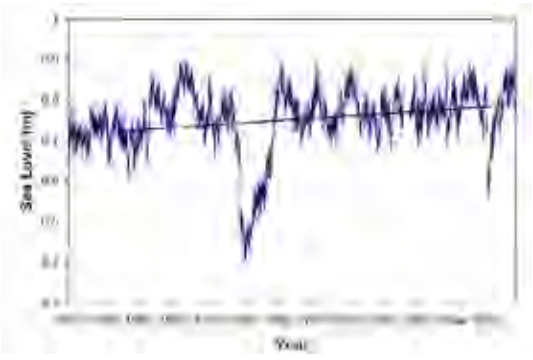
- In rural areas, the risk of contamination of community water sources, which do not receive proper maintenance, at times of torrential rain is increasing.

b) Meteorological observation and disaster prevention

The Meteorological Agency of Samoa predicts that, by 2050, the sea level will rise by 36 cm, rainfall by 1.2%, maximum wind velocity by 7%, and maximum temperature by 0.7℃. The peak daily rainfall in the 1/10 probability year will increase from 200 mm to 300 mm.

6-hour rainfall of 200 mm had a year probability of 1/30 in 2005, however, this is forecast to become 1/23 in 2050, indicating that the short-term rainfall intensity will become stronger.[1]

Future issues in the fields of meteorological observation and disaster prevention are as follows.



Source：Metrological Department of Australia

Figure 2-2.18
Average Sea Level of Apia Port (1993-2005)

- The capital Apia will suffer from constant inundation damage caused by flash floods, while sediment damage will occur frequently in rural parts.
- On coastal lowlands, it is forecast that coastal erosion will advance and that inundated areas at times of high tide and cyclones will grow. It is feared that inundated sections of the island peripheral road will increase, thereby causing the severance of traffic. The tourism industry will be affected.

c) Impact on tourism

Future impacts on the tourism industry will be as follows:

- Samoa has a small-scale economy based on agriculture and coastal fisheries, however, it has recently enjoyed steady economic growth due to the development of tourism, commerce and fisheries since the 1990s. Tourism currently accounts for approximately 25% of GDP.
- Samoa is blessed with beautiful seas and natural resources and its tourism infrastructure is good, The number of tourists visiting the country has increased steadily in recent years, from 77,000 in 1997, to 92,000 in 2003, and 122,000 in 2007 (according to the Tourism Department).
- However, since the tourism industry largely utilizes the coastline, it is especially prone to the impacts of climate change. There is concern that coastal disappearance, torrential rain, flooding, shortages of potable water and so on will have a direct impact.
- Accordingly, the NAPA cites the development and dissemination of climate change adaptation businesses, education of staff in climate change countermeasures, and infrastructure development for climate change countermeasures as important factors for realizing sustainable tourism development.
- Meanwhile, the following factors impede the implementation of climate change countermeasures in the tourism industry: 1) Lack of knowledge concerning climate change, 2) Lack of awareness of climate change countermeasures, 3) Lack of policy coordination with other sector concerned with the tourism industry, 4) Lack of funds for implementing countermeasures, and 5) Uncertainty of future climate change projections.

2) Government Measures and Cooperation Needs

(a) Government measures

Realizing its vulnerability to the impacts of climate change, the Government of Samoa was the

[1] Climate Risk Profile for Samoa

first country in Oceania to compile a NAPA in December 2005. This was followed up by announcement of the Strategy for the Implementation of the NAPA in 2006 (revised in August 2008).

The following items are raised as priority issues in the NAPA: ① Water resources management, ② Forest conservation and forest fire prevention, ③ Climate and sanitation collaboration program, ④ Installation of early warning equipments, ⑤ Agriculture and food safety, ⑥ Land readjustment and strategic management, ⑦ Construction of coastal infrastructure, and ⑧ Protection of sea and land areas.

The Report of the Study on Climate Change Risk in Samoa (CRP) was compiled in 2007. This report, which was compiled based on the Second National Communication Project, verifies the vulnerability of the state in view of climate changes and future forecasts based on the latest information.

The Government of Samoa, as a member of the Oceania community of nations, seeks to pursue peaceful and friendly activities and the national interest. It has attracted the headquarters of the South Pacific Regional Environment Programme (SPREP) to Apia and is playing a central role in the South Pacific region.

Climate change countermeasures are a top priority of the Samoan government. As a general project crossing over all sectors, the Ministry of Natural Resources and Environment (MNRE) has taken the initiative in coordinating the Ministry of Finance and Ministry of Foreign Affairs, etc. and taking countermeasures.

Moreover, as part of the government's climate change campaign, it is continuing to implement education activities for citizens through repeatedly broadcasting public information broadcasts via Samoan TV.

a) Water resources management
Government measures in the area of water resources management are as follows:

- Water Sector Development Plan (2008-2011)
- National Water Resource Plan (2007-2017)
- The government intends to implement sector plans for water resources development, sewerage construction and flooding in future.

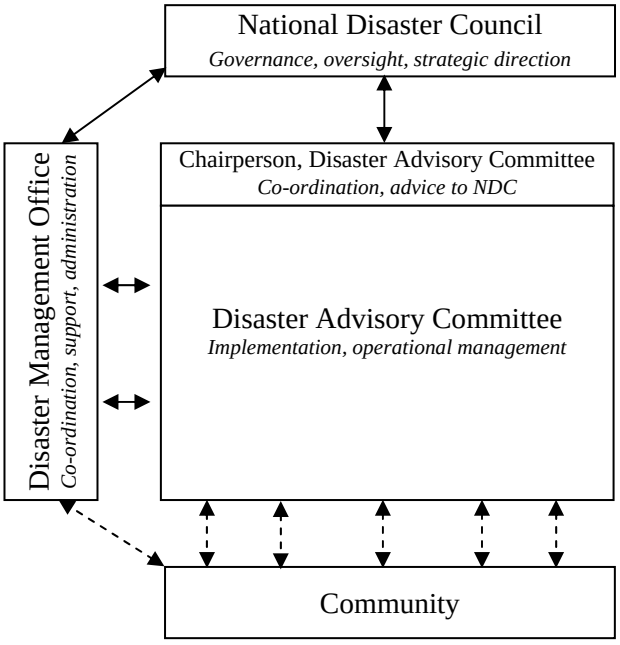
b) Meteorological observation and disaster prevention
Government measures in the area of meteorological observation and disaster prevention are as follows:

- The Disaster and Emergency Management Act was enacted in 2006, and based on this the National Disaster Council chaired by the Prime Minister was established. Under this council, the Disaster Advisory Committee (DAC), which comprises government agency leaders appointed by the Prime Minister, has been established. The DAC conducts assessment and review at times of disaster and emergency, and it also offers recommendations to the National Disaster Council geared to the National Disaster and Crisis Management Plan. Furthermore, it possesses the duty and right to offer support to the disaster countermeasures of related agencies and activity plans of communities. The National Disaster Management Office (NDMO) functions as the secretariat. The NDMO is currently under the supervision of the Meteorological Agency and has three employees. Communications with important government officials are conducted through Short Message Service (SMS) bucket via mobile phones. The NDMO is currently building a disaster database.
- The National Tropical Cyclone Plan was compiled in 2006 and this details steps regarding cyclone countermeasures, preparations, responses and recovery thereof.
- Through the 2008-2013 implementation plan of the National Disaster and Crisis Management Plan, the government aims to review safety measures regarding natural

disasters and disaster prevention education based on information disclosure via the media, and it has implemented workshops at 319 communities throughout the country and is supporting capacity building of media organizations.

- Under support from the World Bank from 1999, the (a) Coastal Infrastructure Management (CIM) Project, (b) Infrastructure Assets Management Project, and (c) Cyclone Emergency Recovery Project risk management component have been implemented over three phases with the following contents:

> Preparation of coastal area hazard maps, participatory coastal infrastructure management strategy, preparation for coastal infrastructure management planning, compilation of coastal protection and coastline recovery, coastal protection



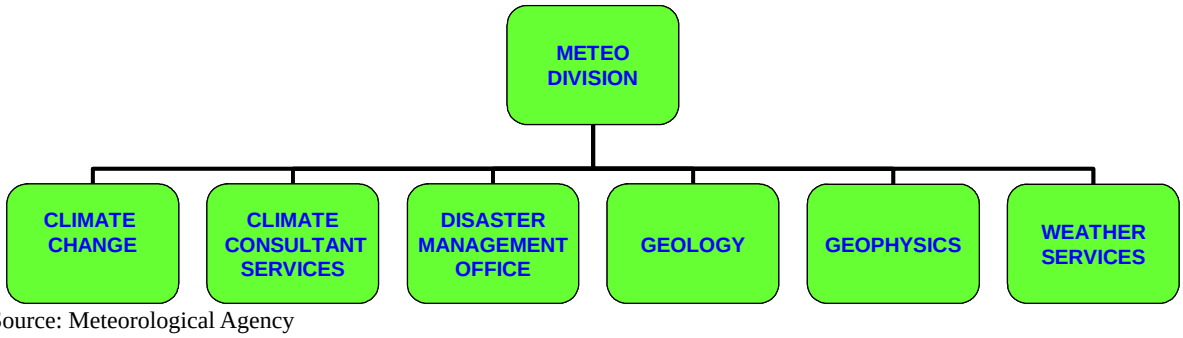
Source: Disaster Management National Action Plan

Figure 2-2.19 Interrelation of Disaster Prevention Organizations

> As risk management for natural disasters caused by climate change: strengthening of national emergency management measures, coastal risk management plans (28 districts), risk mitigation pilot project, GIS

> Infrastructure rehabilitation in line with cyclone and flood risk criteria, strengthening of coastline resistance to climate change, low-cost or free support for adaptation measures on the community level

- In 2008, the Meteorological Agency made a request to the Government of Japan for grant aid (equipment supply) for meteorological observation, an early warning equipments and an airport meteorological observation system. The Meteorological Agency conducts meteorological observation, weather forecasting and affairs concerning meteorological warnings, meteorological statistics, earthquakes, meteorological disasters and climate change. As of April 2009, the Meteorological Agency has 47 employees, of which 17 are assigned to the meteorology division. In 2005, a general automatic weather measurement system was installed under grant aid from Japan. Currently the third generation of senior volunteers conduct support geared to raising the weather forecasting technology of employees.



Source: Meteorological Agency

Figure 2-2.20 Organization of the Meteorological Agency

(b) Cooperation needs

a) Water resources management

Cooperation needs in the field of water resources management are defined as follows.

- In order to respond to emergency water shortages in the capital Apia and throughout the rest of Samoa: development of new water sources, construction of additional distribution reservoirs and provision of water tank trucks
- Promotion of efficient utilization of limited water resources, for example, water leakage countermeasures, water saving measures, etc. (Unaccounted for water currently accounts for approximately 70%).
- Implementation of nationwide survey of the quantity and quality of water resource reserves, water supply and demand survey, and planning of appropriate water supply equipment in areas where water shortages are occurring
- Development of new water sources, construction of additional distribution reservoirs and water leakage improvement project (unaccounted for water currently accounts for approximately 70%) geared to enabling stable water supply in Apia
- Development of new water sources and construction of water supply facilities in rural areas
- Plan of capacity building for managing water quality at water sources and in water supply

b) Meteorological observation and disaster prevention

Cooperation needs in the fields of meteorological observation and disaster prevention are defined as follows.

- Support for strengthening of NDMO organization
- Capacity building regarding assessment of the cost of damages to public facilities caused by natural disasters and evaluations concerning recovery
- Urban river countermeasures on Visigano River (Apia)
- Installation of early warning systems for flooding
- Expansion of meteorological observation facilities and enhancement of meteorological forecasting capacity
- Construction of disaster countermeasure infrastructure on the community base (including coastal erosion countermeasures)

2-2-6 Kingdom of Tonga

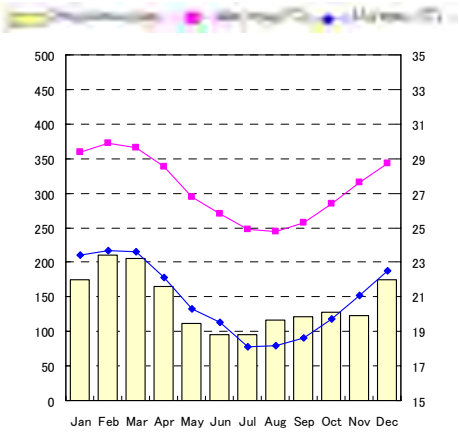
(1) General Condition

1) Population

The total population of Tonga is approximately 102,000, of which around 70% live on Tongatapu Island which includes the capital Nuku'alofa. Concentration of population and urbanization of Capital Nuku'alofa is proceeding. However, land and water resources is limited and lack of them is gradually becoming obvious. Population concentration has made the residential area expanding toward the coastal zone which is vulnerable to natural disaster and their life environment is being deteriorated.

2) Climate

Tonga has a marine climate belonging to tropical rainforest climate, and daily temperature differences are larger than the annual temperature difference. Annual average temperature is 23℃, and temperatures in dray season (June to September) drop to between 17-22℃. In rainy season the temperature increases to almost 30℃, there is a lot of rain and cyclones occur. Temperature doesn't vary much between islands, although there is some disparity in terms of rainfall.



Source：Tonga Meteorological Services

Figure 2-2.21 Temperature and Rainfall in Nuku'alofa

3) Geography

Tonga, situated to the southeast of Fiji and south of Samoa, is composed of four island groups containing around 170 islands with a combined land area of 700 km^2, and it has an exclusive economic zone of 362,000 km^2. The capital city of Nuku'alofa is on Tongatapu Island. Immediately to the east of Tonga, the Tonga Trench stretches from north to south, and the South Pacific Plate cuts under the Indian Plate from the east. Accordingly, Tonga basically comprises volcanic islands.

4) Past Major Natural Disasters

Tonga experiences cyclone damage once every few years. Figure 1 shows changes in annual rainfall in the Ha'apai Group. Annual rainfall fell by 5.7 mm/year on average between 1947 and 2007. Moreover, fluctuations in annual rainfall increased after 1965. Dry spells and occurrences of turbidity in source water have become more common in recent years, and water supply interruptions are also occurring. Trend of sea level fluctuation in Capital city Nukualofa is shown in Figure-2-2.23. Sea level is rising 14mm/year in average since 1993-2001. So salinization of groundwater in coastal aquifer is noticed.

Table 2-2.5 Past Major Natural Disasters

Date	Classification	Fatalities	People Affected
2004, Jan.	Cyclone		
2001, Dec.	Cyclone		16,500
1998, Dec.	Cyclone		3,071
Jan.	Cyclone		500
1997, Mar.	Cyclone		3,000
1990, Feb.	Cyclone	1	3,103

Source：CRED-EMDAT

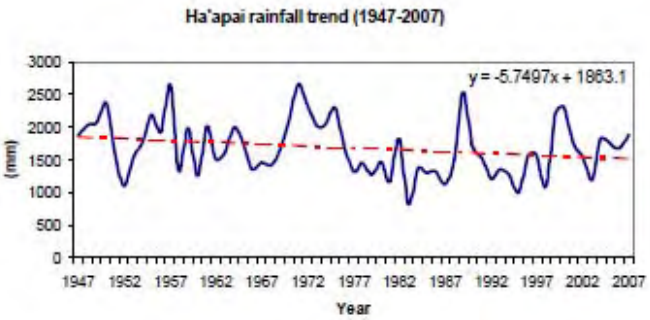


Figure 2-2.22 Changes in Annual Rainfall (Ha'apai Group)

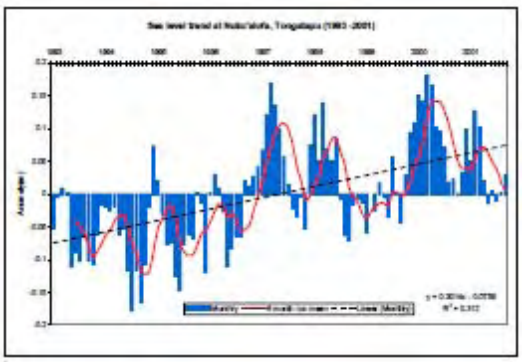


Figure 2-2.23 Trend of Sea Level Fluctuation (Nukualofa)

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources management

There are many small coral islands in Tonga that have no rivers. Accordingly, groundwater and rainwater are the only sources of water. Groundwater exists as a freshwater lens, however, raising of the sea level has some effect on advance of salinization. Due to the high salinity of groundwater, rainwater is used for drinking purposes (the ownership rate of rainwater tanks is approximately 60%). Even in the capital city Nuku'alofa, where a public water supply system has been installed, rainwater is used for drinking, and shortages of potable water become critical during extended dry spells. The following paragraphs describe the vulnerability in water resources management experienced by urban areas and provincial areas in Tonga.

① Urban areas (Nuku'alofa, Tongatapu Island, Neiafu of Vavau Island)

The public water supply in Nuku'alofa is obtained from groundwater via shallow wells, however, salinity levels are high due to effect of salinization. Accordingly, water from the public water supply is used for purposes other than drinking such as washing. Moreover, since water originates from groundwater situated in limestone, it has high calcium content and this causes scaling, sedimentation and blockage of water pipes.

On Tongatapu Island, groundwater exists as a freshwater lens. During the dry season, salinization advances into fresh water lens, effect of which makes salinity level increases. Moreover, increase of the sea level and excessive pumping further aggravate salinization. In the district of Matakieua, which is the water source for Nuku'alofa, the salinity of groundwater is higher with electric conductivity of 1,000uS/cm than general tap water (no more than 500uS/cm).

The Tonga Water Board (TWB) operates water supply in the capital Nuku'alofa (population approximately 30,000) and Neiafu (Vavau Island). However, the TWB is unable to respond to emergency situations in terms of the number of its employees and its management capacity; moreover, it does not possess enough equipment or management personnel (currently only one member and absolutely not enough) to monitor abnormal water quality.

② Provincial areas

The Ministry of Lands, Natural Resources and Environment offers guidance on the operation and maintenance of water supply in provincial areas. Groundwater and rainwater are used as the sources of water in these areas. Since wells are located at an altitude close to the sea surface, the salinization of groundwater of wells is advancing. The salinization of well water is especially marked during the dry season. Accordingly, residents rely on rainwater to provide drinking water. Problems also exist with the maintenance of water supply facilities by village residents, and there are cases where facilities are unused and abandoned.

Many areas in the villages that depend on rainwater do not possess rainwater tanks, and they are confronted with critical water shortages when dry spells are prolonged.

b) Meteorological observation and disaster prevention

Cyclones are the most frequently occurring type of natural disaster in Tonga. In particular, there were cyclone Flora in 1961 and cyclone Juliet in 1973, and cyclone Isaac in 1982 caused massive damage (100,000 people affected and costs of US$21 million). Most the country is flat terrain and, although there is no river flooding, low-lying coastal areas are frequently subject to inundation.

Meteorological information concerning cyclones is obtained from the Fiji Meteorological Service via Emergency Management Information Network (EMWIN). Cyclone warnings are transmitted from the Meteorological Service to the National Emergency Management Office (NEMO), and then from NEMO to related agencies. Cyclone warnings are broadcast in Tongan and English from the radio. Moreover, tsunami information is transmitted from the PTWC to the Meteorological Service, and from there to NEMO.

Within the National Disaster Prevention Plan, disaster prevention education is specified as the responsibility of Tonga Broadcasting Commission. Radio broadcasts of Tonga Broadcasting Commission can be received all over Tonga, while TV broadcasts can be received on Tongatapu Island and Uiha Island only. Vavau Island has AM, FM and local radio broadcasts, while a TV local branch was opened in November 2007. Tonga Broadcasting Commission conducts 24 hours broadcasting a day when cyclones strike, and the Meteorological Service sometimes takes direct charge of broadcasting.

A basic hazard map for tsunami on Tongatapu Island was compiled upon assessing risk by analyzing the altitude data of local land under support from SOPAC in 2007.

At times of disaster, relief activities are effectively provided by the Red Cross, churches and NGOs, and AusAID provides assistance to NGOs as a component of community disaster prevention.

① Urban drainage

The center of the capital Nuku'alofa only has altitude of 1-2 m, and many low-lying areas frequently become inundated following torrential rain in the rainy season. The existing drainage channels are not fulfilling their functions due to the buildup of sediment and blockage of drainage culverts, etc. Due to the poor quality of surface drainage, water buildup caused by the disappearance of rainwater channels, and the lack of drainage channel construction, urban traffic is also being interrupted.

② Coastal erosion

Coastal erosion is advancing in lowlands around the lagoon coast in the northwest of Tongatapu Island (Nukunuku, Tekiu, Masuramea, Neiafu) and Fua'amotu Beach on the southern tip of the island. This is also becoming a critical problem in the Ha'apai Group (Lifuka Island).

③ High tides, etc.

High tide inundation has been confirmed on lowland in Lagoon in the center of Tongatapu Island, the area stretching from Nuku'alofa to the airport, Lifuka Island and so on. When cyclone Isaac struck in 982, 8.8% of Tongatapu Island (23.3 km^2) became inundated with water from high tides.

Photo 2-2.14 Fua'amotu Beach (coastal erosion is advancing)

④ National Emergency Management Office

The National Emergency Management Office is under the jurisdiction of the Ministry of Works, however, it is faced with budget and manpower shortages. Moreover, disaster prevention organization is inadequate in provincial areas. As a result, warnings and relief activities are inadequate, transportation of emergency supplies to small remote islands is

delayed, and means of communication are not secured when cyclones strike.

⑤ Meteorological observation

Due to the deterioration of observation instruments and staff shortages, rainfall observation is not conducted in real time when necessary and observed data cannot be utilized as early warning information at times of flooding. Moreover, meteorological forecasting technology is still weak, though employees are being received training at the Fiji Meteorological Service.

(b) Future Impacts

a) Water resources management

The future impacts on water resources management are as follows.

- In Nuku'alofa, it is forecast that droughts will occur more frequently and there is concern that rainwater for drinking purposes will run short.
- In Nuku'alofa, there is greater risk of more frequent power cuts caused by various disasters and interruption of stable water supply.
- In provincial areas, it is forecast that droughts will occur more frequently and it will become increasingly difficult to secure drinking water.
- The trend of groundwater salinization in line with increase of sea level will advance.

b) Meteorological observation and disaster prevention

The future impacts on meteorological observation and disaster prevention are as follows.

- Due to effect of climate change, it is forecast that cyclones will hit land more frequently, and that the capital Nuku'alofa will experience more frequent inundations and traffic interruptions at times of cyclones and heavy rains. In provincial areas, sediment damage will occur more frequently.
- In the event where a cyclone on the scale of Isaac occurs under conditions of raised sea level (+100 cm), it is forecast that coastal lowlands of less than 4 m altitude on Tongatapu Island will become inundated (37.3 km^2 or 14.1% of the island). [1]

Figure 2-2.24 Forecast High Tide Inundation Areas (white parts)

- Since the National Emergency Management Office has not yet established an emergency supplies transportation system, delays will arise in first aid and relief activities following the occurrence of disasters.
- Since the National Emergency Management Office does not have its own communications network serving provincial areas, and warning broadcasts are not secured on nighttime radio services, thus it is assumed that damage caused by delays in evacuation preparedness will be magnified.

c) Impacts on tourism

The future impacts on tourism are as follows.

- Agricultural products such as pumpkins and coconuts, etc. are major exports from Tonga, however, a perennial trade deficit is continuing and the government is putting effort into promoting tourism and building infrastructure with a view to obtaining foreign currency.
- On the other hand, the absolute number of tourists visiting Tonga is extremely small compared to other Pacific nations (approximately 25,000 in 2003, according to the Tourism Board).
- Accordingly, the tourism industry has been designated as an important sector for economic development within the 8th National Development Plan (2006/7~2008/9), and the government aims to develop industry utilizing its natural and cultural resources.
- In the Second National Communication too, self-sustaining tourism development giving

[1] Research by Professor Mimura of Ibaraki University

consideration to the environment is viewed as necessary.

- However, coastal areas are extremely vulnerable to the effects of climate change such as cyclones, high tides and flooding, and it will be necessary to implement countermeasures while giving consideration to the tourism industry.

2) Government Measures and Cooperation Needs

(a) Government measures

As with the other countries of the South Pacific, Tonga is vulnerable to climate change factors including the El Nino phenomenon. Since it isn't a least developed country (LDC), it hasn't compiled a NAPA, however, it ratified the United Nations Framework Convention on Climate Change in 1998 and is working on climate change countermeasures as a national policy. The central organization in these activities is the Climate Change Project Department in the Ministry of Lands, Natural resources and Environment.

In July 2005, Tonga submitted its Initial National Communication (INC) as prescribed under the United Nations Framework Convention on Climate Change. It is currently working on its Second National Communication (SNC) having 2006~2015 as the project term, and the government is waiting GEF project approval and planning to incorporate climate change countermeasures into its legal systems.

Moreover, the Ministry of Lands, Natural Resources and Environment has compiled its own Climate Change Implementing Schedule in which it has formulated and prioritized concrete steps under the following six themes: ① Natural disasters, ② Coastal environmental conservation, ③ Sustainable agriculture, ④ Minimum forest resources depletion, ⑤ Integrated land utilization, and ⑥ Appropriate solid waste treatment.

Concerning ① Natural disasters, steps are raised in the areas of cyclone countermeasures (development of the observation network), drought countermeasures (installation of storage tanks), and measure to counter increasing sea level (seawalls, relocation of residents, salinization countermeasures).

a) Water resources management

Government measures in the area of water resources management are as follows:

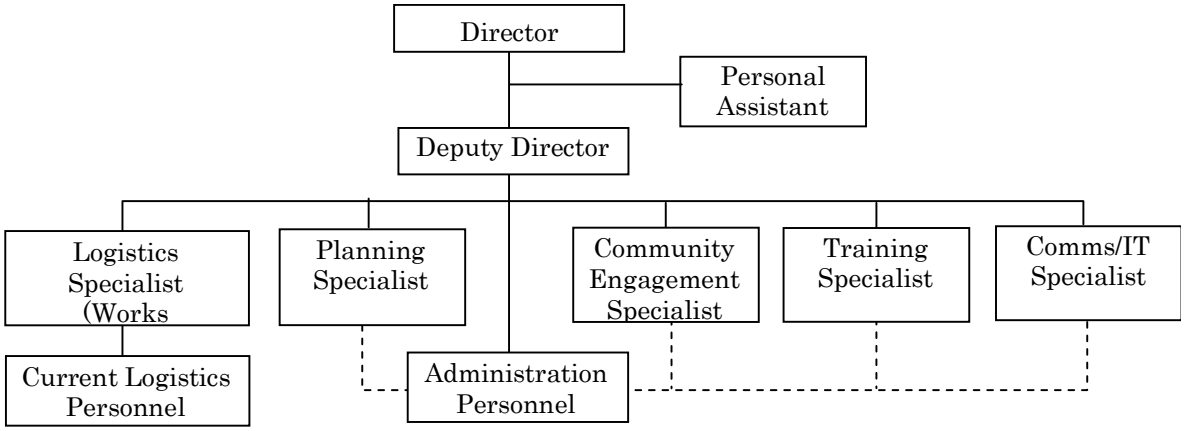
- In the INC, the following adaptation measures are specified from the viewpoint of long-term waster resources management especially ① control of water demand (water conservation measures), ② shift to rainwater utilization, and ③ recharging of water resources, etc.

b) Meteorological observation and disaster prevention

The Meteorological Service has conducted observations since the 1940s and, as a member of the World Meteorological Organization (WMO), collects and manages data according to that organization's standards. Meteorological observation is conducted at six airports on four islands, however, the Meteorological Service only has a total of 16 employees, on which six (five weather forecasters and one climate officer) are assigned to Tongatapu Island. The Meteorological Service headquarters at Fua'amotu Airport is composed of four departments, i.e. the Forecasting Department, Observation and Monitoring Department, Meteorology Department and General Affairs Department, and it conducts observations 24 hours a day with limited human resources (two shifts per day). Personnel receive basic meteorology training at Fiji Meteorological Service. The annual operating cost is 200,000 Pa'anga.

The National Emergency Management Office (NEMO) exists within the Ministry of Public Works, and its activities budget is incorporated into the ministry's budget. It currently has six staff members and functions as the secretariat for the National Disaster Management Committee (NDC). Under the National Disaster Management Plan, disaster management organizations and plans are required to be established on the levels of state, provinces and municipalities. The National Disaster Management Plan undergoes yearly review by the NDC. Means of communication consist of telephones, shortwave radios and satellite phones (iridium),

but shortwave radios are the most frequently used. Satellite phones are used to communicate to the Hawaii Tsunami Warning Center and Fiji Meteorological Service. Concerning activities on the training of human resources, a training course in Comprehensive Hazard and Risk Management was implemented under support from SOPAC in 2001.



Source: National Emergency Management Office

Figure 2-2.25 National Emergency Management Office

At times of disaster, Tonga Defense, which is a member of the NDC, assumes command. At the time of the cyclone disaster in 1982, a relief center was set up inside Tonga Defense. The role of Tonga Defense is to carry out search for missing persons, establish communication with remote islands, conduct resuse activities by plane and boat, and assess the extent of damage.
Patrol boats use HF and VHF waves. Moreover, the military possesses two satellite phone sets (for INMARSAT). Tonga Defense receives training in disaster relief activities from the Australian military once every year.

Government measures in the area of meteorological observation and disaster prevention are as follows:

- In line with enactment of the Emergency Management Act in 2007, the government aims to strengthen organization. It aims to boost personnel in the National Emergency Management Office.
- NGOs are encouraged to actively participate in the disaster prevention field. They actively participate in SOPAC training.
- The Climate Change Implementing Schedule, which corresponds to a NAPA, has been compiled and is being implemented.
- In order to address natural disasters, the Ministry of Lands, Natural Resources and Environment aims to conduct cyclone countermeasures (construction of an observation network), drought countermeasures (installation of water storage tanks), rising sea level countermeasures (seawalls, relocation of residents, salinization countermeasures) and so on.
- The National Emergency Management Plan was compiled in 2008 and this details measures to mitigate disaster risks and address emergency situations.
- The National Emergency Management Plan has been prepared primarily by the Ministry of Public Works in collaboration with the National Emergency Management Office (NEMO) under support from SOPAC.
- Following enactment of the Emergency Management Act in 2007, the National Disaster
- Management Office (NDMO) was renamed as the National Emergency Management Office (NEMO).
- The Ministry of Public Works is planning the construction of embankments and seawalls as structural countermeasures to high tides and coastal erosion on Tongatapu Island.

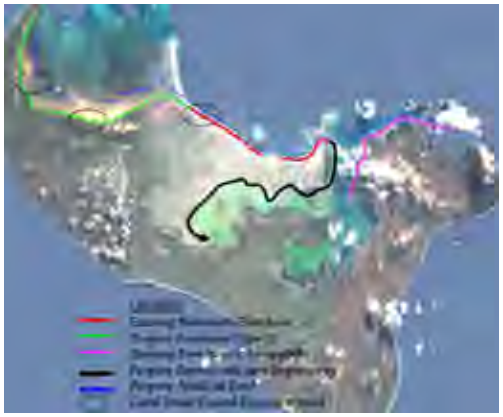
- The Meteorological Service requested Japan to provide senior volunteers (SV) in the field of meteorology and has been striving to improve forecasting technology since March 2009.

(b) Cooperation needs

Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management

- Formulation of plans for the construction of additional clear water reservoirs, water softening machines, portable seawater desalinization devices, etc. in the capital Nuku'alofa, in order to address urgent water shortages over the whole of Tonga.



Source: Ministry of Public Works

Figure 2-2.26 High Tide Countermeasures of the Ministry of Public Works (Draft)

- Promotion of efficient utilization of limited water resources, for example, water leakage countermeasures and water saving measures, etc.
- Implementation of nationwide survey of the quantity and quality of water resource reserves, water supply and demand survey, and planning of appropriate water supply equipment in areas where water shortages are occurring
- Formulation of plan of capacity building for managing water quality at water sources and in water supply in Nuku'alofa

b) Meteorological observation and disaster prevention

- Strengthening of functions of the National Emergency Management Office and promotion of community disaster prevention activities
- Construction of multipurpose cyclone shelters
- Establishment of a disaster prevention radio network (Disaster Radio Net)
- Installation of early warning systems for flooding
- Expansion of meteorological observation facilities, real time transmission of observed data, and enhancement of weather forecasting technology
- Formulation of measures to counter coastal erosion on Tongatapu Island (seawall construction)
- Formulation of high tide countermeasures (tide walls) for low-lying land in and around Nuku'alofa
- Construction of drainage facilities in Nuku'alofa in Tongatapu

2-2-7 Solomon Islands

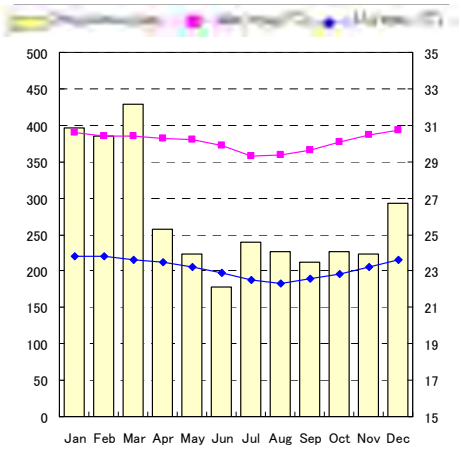
(1) General Condition

1) Population

The Solomon Islands have a population of approximately 534,000, of which approximately 50,000 or 10% live in Honiara. Impact to the coral reef by contaminated drain from Honiara due to population growth is currently crucial issue. Low-lying flat area for residence is located mainly near coastal zone, and the other residence areas are remaining little along deep valley within high mountain. Accordingly, population is concentrating around the coastal zone and even in artificial islands with high risk of flooding. Therefore, coastal area will be more vulnerable to natural disaster and luck of water supply will be more serious due to the impact of climate change in the future.

2) Climate

The climate of the Solomon Islands is characterized by high temperature and high humidity throughout the year. The temperature in Honiara reaches a high of 32℃ and low of 21℃ and displays a mean level similar to that in coastal areas. Rainfall peaks at 430 mm in March and is lowest in August when it falls to approximately 100 mm. Rainfall is relatively low from the end of May to the start of December and the rainy season lasts from January to the start of April. Rainfall is characterized by short bursts of torrential rain.



Source：PIC

Figure 2-2.27 Temperature and Rainfall in Honiara

3) Geography

The Solomon Islands are composed of six major islands and approximately 1,000 smaller islands stretching over some 1,500 km. The national land area is approximately 29,000 km^2 and the exclusive economic zone is 1,350,000 km^2, which is the third largest in the South Pacific region. The Solomon Islands have the second largest land area in the South Pacific and the third largest population. The islands are generally low-lying and covered in tropical rainforests, and they are volcanic islands that experience frequent earthquakes. The central island is Guadalcanal, and the capital city of Honiara is located in the north of this island slightly to the west.

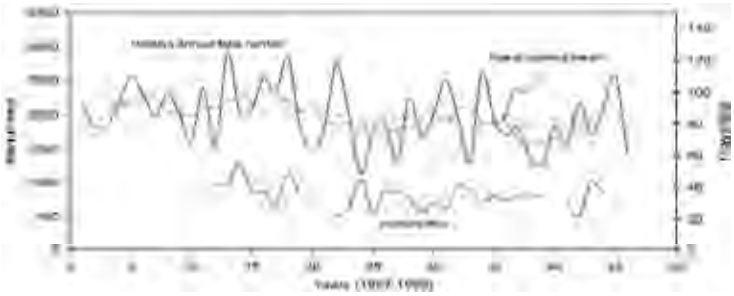
4) Past Major Natural Disasters

The Solomon Islands experienced drought damage in the 1900s, but have suffered cyclone, tsunami and high tide disasters in the 21st Century. Figure 4 shows rainfall and river flow in Honiara. According to this, both rainfall and river flow show a declining trend. Impact of the El Nino phenomenon is minor when viewed as a long-term trend, however, extreme weather occurrences are reported to have become more frequent as a result of El Nino.

Table 2-2.6 Past Major Natural Disasters

year	Classification	Fatalities	People affected
1977	Earthquake	-	More than 1000
1986	Cyclone	103	More than 90,000
1993	Cyclone	5	More than 30,000
1996	Cyclone	3	More than 30,000
2002	Cyclone	-	More than 2,000
2007	Earthquake/ Tunami	52	36,588

Source：National Disaster Management Office



Source: NAPA in Solomon Islands

Figure 2-2.28 Rainfall and River Flow in Honiara

(2) Findings of the Survey of Climate Change Impacts

1) Current Vulnerability and Future Impacts

(a) Current Conditions

a) Water resources management

Annual precipitation in the Solomon Islands, which have a tropical marine climate, ranges between 2,500~4,000 mm. The country has enough river and surface water resources to secure its drinking and living water needs, however, water resources are lacking in low-lying coastal areas and in small remote islands. Moreover, since facilities don't have the capacity to respond to sudden weather changes such as torrential downpour and so on, there is a close relationship between stable water supply and meteorological phenomena.

① Lowlands and small remote islands

Salinization of well water has become an almost continuous phenomenon (not only in the dry season) in remote northern islands such as Ontonjava, the populous island of Malaita, and remote islands such as Kwai and Ngongosila.

Photo 2-2.15 Well on Kwai Island

In coastal lowlands such as the area around Atori on Malaita Island, there is sufficient rainfall to provide drinking water, however, well water has become salinized. This is thought to be because surface water tends to flow directly into the sea without percolating underground. Compared with the situation in other parts of Malaita Island, the level of river and spring water utilization here compared to rainwater is inadequate. Some households have installed rainwater tanks, however, they do not utilize this for drinking due to sanitary concerns, etc. Residents on both islands rely on the government for potable water supply, and they travel to the opposite shore by canoe to procure water. Moreover, villagers adjoining the bay do not drink the groundwater but obtain their drinking water from the government. At the time of the survey (see 7-(1)-2), there were short spells of heavy rain falls every day, however, salinity becomes a lot higher during dry spells.

② Urban parts

In cities (Honiara, Noro, Auki, Tulagi) where the Solomon Islands Waterworks Authority (SIWA) carries out public water supply, flooding is apt to occur in areas where water pipes cross rivers. Problems of water inundation to facilities are also occurring.

③ Provincial areas

In the Solomon Islands, where forestry is a major industry, forests have been cut down to produce timber and make way for cultivated land, however, as a result, this has diminished the water recharging capacity of the said areas and is leading to water shortages.

④ Water resources related organizations

The Ministry of Natural Resources is in charge of the development and management of natural resources throughout the country. Concerning water supply, the Solomon Islands Waterworks Authority conducts public water supply in the capital Honiara and three provincial cities (Auki, Noro and Tulagi). The water supply in other provincial cities is managed by each local authority. Concerning water supply in villages, the Ministry of Health and Medical Services provides guidance on the construction and operation of water supply facilities.

Management of the quality of water supplied in village communities is inadequate due to a lack of inspection kits, etc. Moreover, because personnel of village sanitary control departments do not have the means to travel around local areas, there is insufficient knowledge regarding actual conditions.

b) Meteorological observation and disaster prevention

The Solomon Islands is experiencing more frequent torrential rainfall, longer droughts and rising sea level in recent years, and disasters originating in these phenomena are occurring regularly. In particular, due to the effects of coastal erosion and torrential rain along coastal roads and in communities adjoining rivers, disasters that impart major damage to the lives of citizens are occurring.

① Road inundation

The road between Dala and Maluu on Malaita Provice is the main road on the island, however, coastal erosion is advancing in many parts that face the ocean.

Since this road connects copra cultivation areas and heavily populated areas, it is an important route for local industry, however, parts of it become inundated and impassable at high tide.

In future, it is forecast that the impact of rising sea level will cause inundation to occur in more places (see 7-(1)-4).

Photo 2-2.16 Area around Maluu (where inundation is most pronounced)

② Flooding and debris flow damage

Torrential rain that occurred from the end of January to the beginning of February 2009 in Guadalcanal caused flooding and debris flow damage in Sasaa River late at night, and this led to four people losing their lives and 525 people suffering damage.

As a result, damage occurred along the trunk road and on bridges leading out of the capital Honiara, and this was only repaired just before the Study (see 7-(1)-7).

Photo 2-2.17 Remains of a Settlement Washed Away by Flooding

③ Disaster management capacity

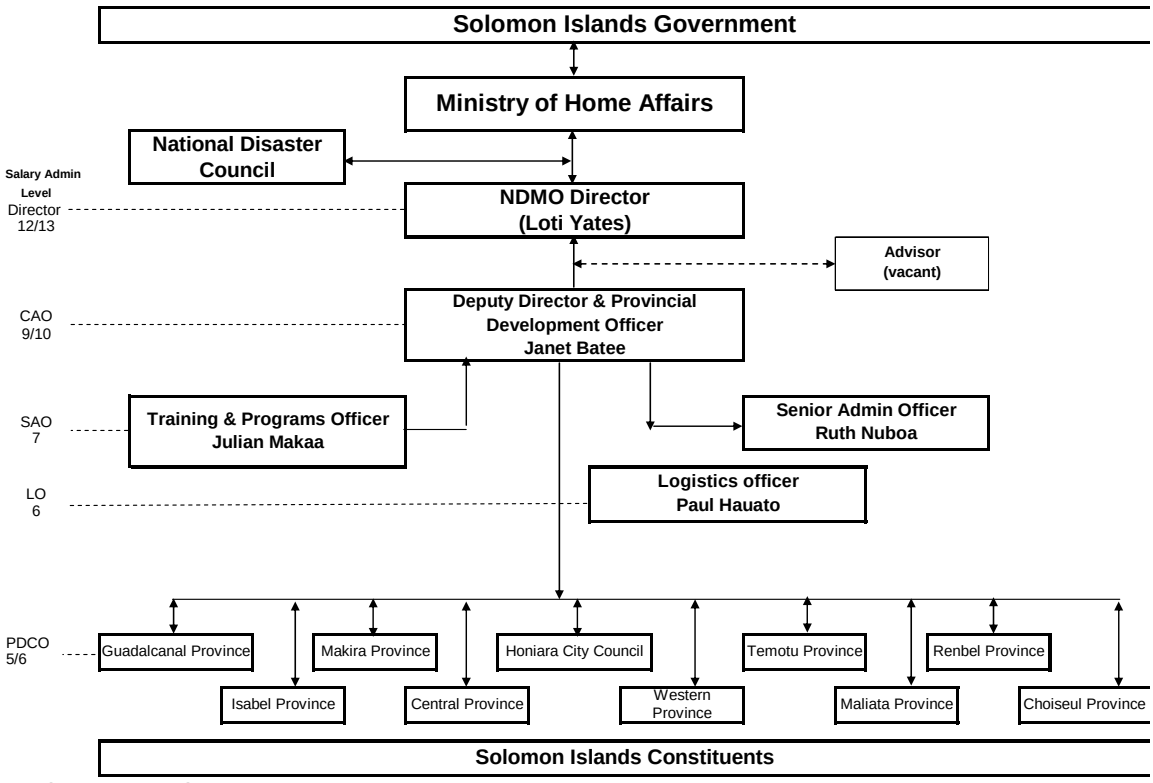
At the time of the flood and debris flow damage that occurred in Sasaa River, the Ministry of Environmental Conservation and Meteorology and the Disaster Management Office failed to issue cautionary warnings or advisories to residents. On the night of the disaster, the Ministry of Environmental Conservation and Meteorology gave forecasts of rain (current rain situation and prospects) via radio broadcasts, however, it was totally unable to predict risks of localized torrential downpour.

The Disaster Management Office failed to collaborate with the Ministry of Environmental Conservation and Meteorology in examining the possibility of disaster occurring, and neither emergency disaster broadcasts for preventing secondary disasters nor broadcasts for advising on the torrential rain that continued for a few more days were given. Moreover, the agencies in charge of disaster response had not implemented training on how to deal with disasters. Accordingly, the disaster was largely aggravated by the lack of meteorological and disaster forecasting technology and disaster management capacity.

Disaster-related legislation and standards of conduct in the Solomon Islands have not been revised at all since going into effect in the late 1980s. Under the present legislation, the Disaster Management Office must pay broadcasting charges if it needs to issue evacuation warnings to residents over the radio.

Airport meteorological observation posts are operated 24 hours a day, however, telephones are the only available means for giving emergency communications to the Disaster Management Office and provincial disaster committees.

Moreover, the Disaster Management Office has nine members of staff with one member assigned to each provincial disaster committee, and this setup is not enough for responding to emergencies.



Source: NDMO

Figure 2-2.29 National Disaster Management Office Organization Chart

④ Meteorological observation and disaster prevention organization

The Environment and Meteorology Department under the Ministry of Environmental Conservation and Meteorology has 87 permanent employee positions, however, 29 of these are vacant.

Concerning disaster management, the National Disaster Committee, National Disaster Management Office and 10 provincial offices are organized under the Ministry of Internal Affairs. AusAID is offering support for the strengthening of disaster management offices between 2005 and 2010.

The Solomon Islands Broadcasting Corporation conducts enlightenment activities concerning climate change and disaster prevention.

⑤ Meteorological observation and forecasting

There are currently five meteorological observatories in the Solomon Islands with plans to add further equipment in two more provinces; however, weather forecasters do not posses sufficient meteorological forecasting ability including local forecasting.

Observations are carried out every three hours from 05:00 to 23:00, i.e. seven times per day. Three members conduct observations over two shifts (5:00～14:00, 14:00～23:00). The only meteorological observatory that operates on a 24-hour setup is the airport observatory in Honiara. Moreover, numbers of forecasters are especially restricted (currently only five).

In future, due to the impact of climate change, it is predicted that disaster forecasting will become even more difficult.

⑥ Infrastructure development

Major bridges are designed to withstand peak floods with a 50 year probability, however, there are no criteria for other structures. As a result, numerous bridges suffered damage during

flooding that occurred at the start of this year.

It is not clear what kind of design must be implemented in order to consider vulnerability based on the future impacts of climate change, however, the approach of depending on judgments from individual projects could potentially incur huge budget burden.

Photo 2-2.18 Collapsed Bridge

⑦ National awareness

Citizens who have never experienced disasters tend to have low awareness of risks and are in danger of being caught up in future disasters.

As the likelihood of unexpected disasters increases due to the effects of climate change in the future, it is necessary to enhance knowledge about disasters on the community level. Moreover, people tend to view prolonged localized downpours as an outcome of climate change, however, they are at risk of overlooking the impact of environmental deterioration brought about by the concentration of population. Accordingly, it is necessary to obtain understanding for government environmental countermeasures through stimulating national awareness.

(b) Future Impacts

a) Water resources management

Water resources are expected to become depleted due to less rainfall brought about by climate change, conversion of forests into farmland and reduction of water source recharging areas, and the salinization of groundwater in coastal areas is expected to advance as the sea level increases.

b) Meteorological observation and disaster prevention

More and more coastal roads will become inundated in line with the rising sea level, and it is expected that local torrential rain will cause more frequent flooding and sediment disasters. Moreover, sediment disasters will cause the destruction and loss of arterial roads and bridges, and it is thought that the cost of restoring such facilities will place a heavy burden on government finances.

c) Impact on tourism

The Government of the Solomon Islands maintains that climate change isn't having any short-term effects, however, increasingly frequent disasters have the potential to deter tourists. Moreover, since the Solomons depend on scuba diving and so on to boost the tourism industry, the blanching of coral reefs and other changes in marine ecosystems could badly affect the economy in the long term.

As is described under the government measures in the next section, emphasis is being shifted to tourism development, fisheries and marine resources as the pillars of economic vitalization, and in order to execute these strategies, it will be necessary to disclose more information about disasters and prepare an environment in which tourists can travel in safety.

2) Government Measures and Cooperation Needs

(a) Government measures

The Government of the Solomon Islands compiled the Medium Term Development Strategy 2008 to 2010 in June 2008. The strategy outlined in this is founded on self-development for the autonomy of residents via the promotion of rural communities, achievement of the millennium development targets and vitalization of the economy, etc.

Government ministries have each prepared a Corporate Plan. Concerning environment and meteorology, the Ministry of Environmental Conservation and Meteorology compiled the Corporate Plan 2008-2010 in January 2008 and is working on environmental conservation, studying the ecosystem, addressing global warming and rising sea level, providing meteorological services and so

on.

The NAPA was formulated in December 2008 and proposes activities in the following seven areas: ① Agriculture and food security, water and sanitation, health, education, ② Submersion countermeasures on lowland and artificial islands, ③ Solid waste management, ④ Coastal erosion, ⑤ Fisheries and fishery resources conservation, ⑥ Infrastructure construction, and ⑦ Tourism. Of these items, donor support has been secured for the first item, while the government hopes to seek donor support for the remaining items from now on.

a) Water resources management
In the field of water resources management, the Natural Resources, Department of Mines and Energy has compiled the Hydrology and Water Resources Management Work Plan 2009 and is aiming to tackle water governance, water supply monitoring and building of a database of water resources.

b) Meteorological observation and disaster prevention
Various assessment have been conducted and report compiled concerning disasters and disaster prevention conditions, and efforts are being made to unify disaster information. Moreover, Provincial Disaster Committees stage public workshops and are working to conduct enlightenment activities.

(b) Cooperation needs
Upon confirming with the counterpart agencies, cooperation needs in the fields of water resources management, meteorological observation and disaster prevention are defined as follows.

a) Water resources management
- Measures for protection of water supply facilities at times of torrential rain
- Well salinization countermeasures
- Mitigation of dry season water shortages through promotion of efficient spring water use
- Enlightenment of village residents concerning conservation of water resources
- Village water supply sanitary management setup and technology enhancement

b) Meteorological observation and disaster prevention
- Measures to counter disasters caused by localized torrential rain, drought and coastal erosion, etc.
- Measures to counter flooding of trunk roads (bridges) and submergence and erosion of coastal roads (regular occurrences with the spring tide)
- Enhancement of meteorological and disaster forecasting technology
- Support for establishment of disaster-related legislation and standards of conduct
- Establishment of emergency communication network for use at times of disaster
- Compilation of infrastructure design criteria
- Enlightenment activities concerning disaster prevention

2-3 Donor Support

(1) Local Agencies

Donor support for the Pacific island nations in the area of climate change can be classified into the following four categories: ① Support conducted through local agencies, ② Support conducted through international agencies, ③ Bilateral support, and ④ Support conducted by NGOs.

In particular the donors that are active in this region conduct programs via local agencies that count the island nations as their members. These local agencies form a federation in the shape of the Council of Regional Organisations in the Pacific (CROP), which includes 22 Pacific island nations and regions as members and operates 10 local organizations.

The member nations and local agencies of CROP are as indicated below.

Table 2-3.1 Council of Regional Organizations in the Pacific: Member States and Local Agencies

Member states (22 countries and regions)	American Samoa, Cook Islands, Federated States of Micronesia, Republic of Fiji, French Polynesia, Guam, Republic of Kiribati, Republic of the Marshall Islands, Republic of Nauru, New Caledonia, Niue, Northern Mariana Islands, Republic of Palau, Papua New Guinea, Pitcairn Islands, Republic of Samoa, Solomon Islands, Tokelau, Kingdom of Tonga, Tuvalu, Republic of Vanuatu, Wallis and Futuna
CROP agencies	① Forum Secretariat ② Secretariat of the Pacific Community: SPC ③ The Secretariat of the Pacific Islands Applied Geo-Science Commission: SOPAC ④ The Secretariat of Pacific Regional Environmental Programme: SPREP ⑤ University of South Pacific: USP ⑥ Forum Fisheries Agency: FFA ⑦ South Pacific Tourism Organisation ⑧ Pacific Islands Development Programme ⑨ Fiji School of Medicine ⑩ South Pacific Board for Educational Assessment

CROP agencies implement separate projects based on financial backing from the member states as indicated above. However, they frequently implement wide area projects using funds given to CROP by multilateral and bilateral donors, building cooperation between the member states.

The following paragraphs describe the initiatives taken by the major agencies to counter climate change in the fields of water resources, meteorological observation and disaster prevention.

a) SOPAC

SOPAC, which is funded by AusAid, NZAid, the World Bank and EU, etc., implements wide area support projects for countering climate change in the fields of water resources, meteorological observation and disaster prevention.

SOPAC contributes to the region as a research agency and it has accumulated a diverse stock of knowledge through its implementation of wide area projects. In future, it will be necessary to implement propsoed projects of adaptation measures through utilizing the reports that have been compiled by SOPAC.

Tables 2.3.2~8 show the conditions of assistance by donors concerning climate change countermeasures in the fields of water resources, meteorological observation and disaster prevention, as compiled by SOPAC.

b) SPREP

SPREP, which is funded by the World Bank and so on, conducts wide area support geared to addressing climate change. Based on the Pacific Islands Climate Change Assistance Programme and so on, it supports the compilation of country-separate reports and offers training support in the areas of vulnerability and adaptation measures.

The wide area policy on climate change in Oceania was agreed on in the Niue declaration at the Forum of Pacific Islands held in August 2008. Within this, it was decided to entrust to SPREP the strengthening of meteorological observation, arrangement and provision of information concerning

climate change, strengthening of examination of adaptation and mitigation measures, and strengthening of bargaining capacity in the UNFCCC. Moreover, SPREP plays a central role in the region concerning impacts on the ecosystem.

c) USP

The USP carries out human resources development concerning environmental problems and sustainable development in the Pacific region. Utilizing financial backing from the Global Environment Facility (GEF), it implements projects for consolidated technique models concerning coastal vulnerability assessment and adaptation regarding climate change.

Concerning human resources development, which is a perennial issue in the field of climate change countermeasures in the Pacific region, much is expected from advanced education institutions such as USP.

(2) International Agencies

Various initiatives, mainly comprising soft support such as human resources development and enhancement of administrative capacity, etc., are being promoted based around United Nations agencies. Moreover, utilization of GEF funds is being promoted through the compilation of NAPAs.

a) United Nations Development Plan (UNDP)

The UNDP gives priority to support for policy and system formulation such as NAPA preparation and so on. Also, utilizing GEF funding, it implements small-scale projects targeting communities.

b) World Bank

The World Bank has set up the Clean Technology Fund and Strategic Climate Fund to strengthen its support for mitigation and adaptation measures in the climate change field. Utilizing these two funds, it conducts support for coastal infrastructure management (Samoa), cyclone countermeasures (Samoa and Tonga) and adaptation projects (Kiribati), etc.

c) Asian Development Bank (ADB)

The ADB regards climate change adaptation measures as the central element of its development program and intends to strengthen support in this area in future. It has established a climate change adaptation fund and, via the Water Finance Partnership Facility and Wide Area Technical Cooperation for Climate Change Adaptation Measures in Asia and Oceania and so on, it supports climate change measures in Pacific island nations and places emphasis on support for infrastructure development projects.

d) Global Environment Facility (GEF)

The GEF is a fund mechanism that was established with the objective of resolving environmental problems for promoting sustainable development, and the World Bank, UNDP and SOPAC, etc. are its project implementing agencies. In Oceania, it is scheduled to implement wide area support for the consolidated securing of water resources and drainage management utilizing GEF funds. In future, it is likely that GEF funds will be utilized primarily for adaptation measures proposed in NAPAs.

(3) Bilateral Donors

The biggest donor in the field of climate change is Australia, which not only provides funding to regional agencies but also implements projects via AusAID.
Moreover, AusAID in 2008 declared A$150 million of support mainly for Pacific countries that are vulnerable to climate change over the next three years, and it is expected that concrete cooperation projects with other donors will rapidly progress from now on.

a) AusAID

AusAID widely conducts support in the seven countries targeted by this JICA Study, with the type of wide area support, bilateral support and NGOs support employing SOPAC and SPREP. It most commonly implements projects by provision of funds to SOPAC and so on. In the field of water resources management, it has conducted support for water supply in Tonga, Vanuatu and Samoa. Moreover, in the field of meteorological observation, based on the South Pacific Sea Level and Climate Monitoring Wide Area Support Project, it aims to build basic data on rising sea level. It is also implementing or is planning to implement wide area support projects in the meteorology and climate

field. Concerning disaster prevention, it is implementing a wide area support project that has SOPAC as the implementing agency.

AusAID views disaster countermeasures and climate change countermeasures as the same thing and supplies emergency equipment to meteorological services and implements training at AusAID headquarters as a part of its disaster relief activities. In addition, it implements community-based disaster risk mitigation programs in Tonga and the Solomon Islands.

b) EU

The EU primarily implements wide area support projects concerning integrated water resources management via provision of funds to SOPAC.

c) NZAID

Support by NZAID centers on wide area programs implemented via SOPAC and SPREP. Rather than conducting support specializing in climate change, NZAID prefers to address the problem via projects concerning such areas as water resources development and supply, natural disasters, and community and government environmental problems.

d) United States

The United States has so far not been very active in support activities in the Pacific region, however, it intends to strengthen this area in future and is currently building the Pacific Climate Information System. The Study Team visited American meteorological observation in Nauru during the field surveys.

(4) NGOs

NGO activities in the fields of water resources management, meteorological observation and disaster prevention in the seven target countries of this JICA Study are reportedly conducted on the community base, however, no mention was made of NGO activities during the hearings with related agencies in the Study.

(5) List of Main Support Projects

The following tables show the major support activities being conducted with respect to climate change in each support field.

Table 2-3.2 Wide Area Support for Disaster Management (Adaptation Measures)

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Climate change and disaster countermeasures	Program	Under implementation	UNOCHA	600,000	Pacific region
Stabilization and enhancement of recovery capacity with respect to natural disasters and climate change	Program	Under implementation	UNESCO		Pacific region
Support by SOPAC and MOU for 3 programs: Ocean and Islands, Community Lifelines, and Community Risk	Program	2006-2008	AusAID	5,400,000	SOPAC：13 countries and regions (Cook Islands, Fiji, Guam, Micronesia, Kiribati, Marshall Islands, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Support for national action plan implementation (with SOPAC as the implementing agency)		2008-2011	AusAID	2,265,000	12 countries and regions (Cook Islands, PNG, Samoa, Solomon Islands, Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Tonga, Tuvalu)
Natural resources and disaster management in the Pacific region	Program	Draft Program strategy to be released in 2008	NZAID	To be funded out of NZ$50 million of support between 2008-2015	Pacific region

Disaster risk mitigation (with SOPAC as the implementing agency)	Program	2007-2011	EU	5.96 million	7 countries (Nauru, Marshall Islands, Palau, Solomon Islands, Tonga, Tuvalu, Micronesia)
Strengthening of humanitarian emergency measures for mothers and children in Oceania (implemented as a UNICEF program)	Program	2008-2011	AusAID	1,000,000	5 countries (Fiji, Solomon Islands, Kiribati, Vanuatu, Samoa)
Integrated disaster risk mitigation by communities in Oceania by the National Council of Churches in Australia	Project		AusAID	2,564,600	4 countries (Fiji, Solomon Islands, Tonga, Vanuatu)

Source: SOPAC

Table 2-3.3 Bilateral Support (Including that by International Agencies) for Disaster Management (Adaptation Measures)

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Emergency and risk management capacity development in the cyclone emergency recovery and management project		2002-2005	World Bank	1.8 million	Tonga
Risk management in the infrastructure assets management project 2nd phase		2003-2007	World Bank	2.0 million	Samoa
Risk management in the cyclone emergency recovery project		Under implementation	World Bank	4.1 million	Samoa
Strengthening of disaster recovery planning and adjustment capacity (bottom level, collaboration with emergency support grant aid)		2007-2009	ADB	800,000	Solomon Islands
Solomon Islands emergency support program	Program	2007-2009	ADB	8.95 million	Solomon Islands (Ministry of Infrastructure Development)
Improvement of emergency countermeasures preparedness in communities	Program	2008-2011	AusAID	975,864	Vanuatu

Source: SOPAC

Table 2-3.4 Bilateral Support (Including that by International Agencies) for Infrastructure Development (Adaptation Measures)

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Samoa coastal infrastructure management		1999-2004	World Bank	2.3 million	Samoa
Afulilo environmental countermeasures strengthening	Technical Assistance	2008-2010	ADB	1,200,000	Samoa
Domestic maritime support	Project	2009-2018	ADB EU	14.0 million 5.25 million	Solomon Islands (Ministry of Infrastructure Development)
Highland road construction investment	Program	2009-2018	ADB Others	400 million 150 million	PNG (Department of Works)
Remote islands development center (water supply and public sanitation)	Technical Assistance	Approved in December 2004	ADB	800,000	Kiribati(Ministry of Line and Phoenix Islands Development)

Source: SOPAC

Table 2-3.5 Assistance for Water Security (Adaptation Measures)

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Pacific Water Circulation Observation System	Project	2006-2009	EU	*2.3 million Euro	Oceania
Pacific region hydrological training	Program	2003-	Implementing agencies: , SOPAC, WMO, UNESCO	240 k NZ$	Oceania
Sustainable and integrated securing of water resources and wastewater management	Project	Waiting for GEF approval	GEF	10,700,000	14 countries (Cook Islands, Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, ニウエ, Palau, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Integrated water resources management in the Pacific Ocean	Program		EU	2.8 million	14 countries (Cook Islands, Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Kiribati Climate Change Adaptation Project (Phase 2)	Project	2001-2009	AusAID/World Bank	7.4 million	Kiribati
Safe Water Plan		2008-2009	AusAID/WHO	750,000	Undecided
Pacific water database and quality control initiative			NZAID		Oceania
Bilateral water program (improvement of water supply)		Undecided	NZAID	2.9 million	Tonga

Source: SOPAC

Table 2-3.6 Assistance for Coastal Land Management (Adaptation Measures)

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Samoa, coastal conservation (NAPA)	Project	2007-2008	LDC UNFCCC Fund	140,000	Samoa
Sustainable land utilization program	Program	Under implementation	UNDP	500,000	Samoa, Niue
Samoa ocean conservation	Project	Under implementation	UNDP	110,000	Samoa
Pacific Coral Triangle coastal and ocean resources management strengthening	Project	2008-2009	5 countries' governments and ADB, etc.	40 million (ADB:850, 000)	5 countries (Fiji, PNG, Solomon Islands, Timor, Vanuatu)
Safe soil concerning environmental protection in Tarawa	Project	2008-2011	EU	2.2 million	Kiribati
Mangrove regeneration	Project	2008-2011	AusAID	2.0 million	Samoa

Source: SOPAC

Table 2-3.7 Assistance for Research, Training, Media Awareness Enlightenment and Advocacy

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Media training course concerning climate change	Workshop	Finished in 2008	UNESCO	80,000	Samoa
Climate change and climate forecasting	Program	Under implementation	WMO	500,000	Oceania
Global climate observation system in Pacific nations		Under implementation	SPREP,NOAA, AusAID,USGCOS, WMO	110,000	Oceania
Sea level and climate monitoring project in the South Pacific (Phase 4)	Project	2006-2010	AusAID	9.0 million	12 countries (Cook Islands, Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Climate forecasting project in Pacific nations (Phase 2)	Project	2005-2009	AusAID	3.0 million	10 countries (PNG, Solomon Islands, Vanuatu, Kiribati, Tuvalu, Fiji, Tonga, Samoa, Niue, Cook Islands)
Pacific climate data redress (Phase 1)	Project	2005-2006	AusAID	84,324	5 countries (Kiribati, Vanuatu, Solomon Islands, Fiji, PNG)
Monitoring system for firm and reliable data (database management)	Project	2006-2007	AusAID	136,950	6 countries (Kiribati, Vanuatu, Solomon Islands, Fiji, PNG, Samoa)
Climate data redress	Project	2007-2008	AusAID	75,000	4 countries (Cook Islands, Niue, Tonga, Tuvalu)

Source: SOPAC

Table 2-3.8 Assistance concerning Climate Change Mainstreaming and Sustainable Lifestyles

Title	Form of Support	Term (years)	Donor	Budget (US$)	Targets
Kiribati Adaptation Project preparatory phase (KAPI)		2003-2005	World Bank (using the climate change fund of the Government of Japan)	0.64 million	Kiribati
Kiribati Adaptation Project execution phase (KAPII)		2006-2010 (1 year behind the original schedule)	World Bank AusAID	*AUD 2.4 million *AUD 2.8 million	Kiribati
Capacity building concerning climate change	Program	Under implementation	UNEP SPREP, etc.		Oceania
Adaptation measures for climate change in the Pacific (PACC)	Program	Already approved by the GF secretariat	GEF	13.1 million	14 countries (Cook Islands, Fiji, Micronesia, Kiribati, Nauru, Niue, Palau, PNG, Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Mainstreaming of environmental problems in economic and development plans		Dec.2008	ADB	600,000	10 countries (Micronesia, Kiribati, Palau, Cook Islands, PNG, Marshall Islands, Samoa, Solomon Islands, Vanuatu)
Vulnerability and adaptation initiative		2004-2009	AusAID	4.0 million	6 countries (Fiji, Solomon Islands, Samoa, Tonga, Tuvalu, Vanuatu)
Assessment of vulnerability to climate change			AusAID	15.0 million	Oceania

Source: SOPAC

2-4 Environmental and Social Impact Assessment and Climate Change

The countries targeted in the Study – Nauru, Kiribati, PNG, Vanuatu, Samoa, Tonga and the Solomon Islands – have established environmental legislation that includes stipulations on environmental impact assessment. Environmental impact assessment systems are generally the same in all countries and include requirements for preliminary assessment in line with assessment and post-monitoring, etc. An outline of the environmental social impact assessment systems in each country is indicated in Appendix-8.

Since the environmental impact assessment systems in each country are similar to the system in Japan, when implementing Japan's support projects, it will be effective to dispatch consultants who are well versed in the Japanese environmental impact assessment system. However, since the items, scope and degree, etc. of environmental impacts caused by development activities in overseas countries sometimes greatly differ from those in Japan. When implementing environmental impact assessments in support projects, it will be necessary to adopt a careful approach upon fully surveying data and implementing field surveys on environmental conditions in the target countries and areas.

Concerning climate change, two scenarios can be considered, i.e. cases where development activities have an impact on climate change (Case 1), and cases where the environmental impact of development activities changes in line with climate change (Case 2).

Examples of Case 1 activities are such as foreign resources development and switching of land use, etc. in some of the target countries. It will be necessary to implement appropriate alternative measures or mitigation measures based on the computation of CO_2 over the life cycle of projects.

In example of Case 2 activity, it is though to be difficult to forecast wide area and long-term environmental changes and to implement accurate environmental impact assessments. In addition to fully considering current preventive measures and alternative measures corresponding to potential environmental changes, it is desirable to compile plans for environmental management and monitoring after project implementation. It is desirable to support for the enhancement of monitoring capability by combining the introduction of observation system with measurement instruments and implementation of organizational strengthening and human resources development.

In any case, it is important to take consideration on impact to social environment of recipient countries in implementation of projects, utilizing knowledge and experience of Japan. Thus it is requested to include social environmental consideration into the projects, based on full communication with the countries of the South Pacific Islands.

CHAPTER 3 Direction of Cooperation Geared to Mitigating Vulnerability

3-1 Basic Policy

(1) Background of Vulnerability

The Pacific countries targeted in the Study have the topographical features of island nations combined with population concentration into capital cities, etc. and underdevelopment of socioeconomic infrastructure. As a result, these countries have difficulty responding to sudden weather changes and the natural disasters imparted by them.

Target countries consist of various sizes of islands, from huge volcanic islands to small coral reef islands with width of several tens of meters. Smaller islands have lower ground elevation. For example, ground elevation of a coral reef island is only several meters. It will be easily submerged by rising sea level, and also subject to be damaged by high tide and high wave. Adding to above topographical vulnerability, target islands are located in zone of tropical rainforest climate usually with enough precipitation, and consequently flooding and sedimentation disasters are apt to occur. Furthermore, damages by the disasters mentioned above will worsen by cyclones that occur frequently in the South Pacific Region. Potential of water resources is limited by the size of the islands. Water resources are rich in big islands, but it becomes poorer as size of island becomes smaller. Area under the influence of groundwater salinization near the sea coast is particularly poor in water resources. Rainfall is usually only water sources in small coral reef islands, which is particularly vulnerable to drought.

The people living in these island nations traditionally have lived in coexistence with nature. For example, on low-lying land, the people have depended on ocean resources and formed communities mainly in coastal areas. In the highland areas, they have sought farmland and built communities close to rivers and have lived with the benefit of abundant water which provides all the resources they need to live. However, due to the entry of the modern currency-based economy and Western culture, people's values have changed and populations have come to concentrate in capital cities and urban areas with high economic value.

As a result, due to the limited land area and constraints of traditional land ownership systems, migrants in many Pacific island nations have been unable to secure land and they have come to live in coastal landfills and marshlands at high risk of flooding. Population concentration has led to the artificial transformation of coastlines in order to obtain living space, and this is having an impact on the littoral drift of coral and foraminifera, etc. Moreover, due to the cutting of forests including mangroves and occurrence of sewage problems caused by population concentration, there are reports of coral reefs becoming deteriorated and blanched.

These recently occurring conditions in the Pacific island nations are triggering inundation of coastal residences during high tide, transformation of marine habitats due to the depletion and disappearance of mangroves and coral reefs, and ultimately the depletion of marine resources in coastal areas. Furthermore, the wave breaking functions of mangroves, coral reefs and sand beaches are being diminished, thereby leading to the advance of coastal erosion and so on. As these negative impacts become more and more manifest, the recent changes in social conditions have come to reverse the hitherto peaceful coexistence with nature and instead threaten the natural environment.

When examining the direction of adaptation and mitigation measures geared to reducing vulnerability to climate change in the fields of water resources, meteorological observation and disaster prevention in Pacific island nations, it is necessary to consider countermeasures with respect to integrated impacts comprising pre-existing vulnerability and the effects of climate change.

(2) Impacts of Climate Change

Against the above background of vulnerability, the primary impacts of climate change in the Pacific region can be summarized into the following two elements:

i. Impacts of rising sea level such as submergence of lowland, intensification of inundation, intensification of coastal erosion, infiltration of saltwater to freshwater lens and so on; and

ii. Impacts of extreme meteorological phenomena such as frequent occurrence of torrential rain and prolonging of dry spells and droughts.

These primary impacts are thought to trigger secondary impacts explained below. That is; sediment disasters occur more frequently, dry spells lead to potable water shortages, droughts cause breakdown of the food supply and demand balance, and community social activities are affected. Furthermore, the costs of implementing intermittent and increasingly frequent countermeasures and repairing broken infrastructure can place a burden on national economies, thereby contributing to the neglect or worsening of poverty.

(3) Principles of Countermeasures

Out of the generally available adaptation and mitigation measures for vulnerability[1], the direction of cooperation will be examined according to the following principles upon considering needs in the target countries and the features of Japanese measures:

① Priority to countermeasures that consider human security
② Coexistence of climate change countermeasures and sustainable development
③ Adaptation measures and mitigation measures suited to local social conditions
④ Consideration for utilizing the natural forces of the Pacific region and realizing coexistence with nature
⑤ Feasibility and relevance of NAPAs and adaptation measures or their equivalent in target countries
⑥ Utilization of Japanese experience and technical characteristics
⑦ Cooperation based on collaboration with associated aid agencies

For example, concerning countermeasures for rising sea level, the principles of retreat, adaptation and protection have been traditionally recommended, however, in the case of Pacific island nations, it is often difficult to take retreat measures because land available for use is restricted and traditional land ownership systems are a hindrance (give consideration to countermeasure principle ③). Furthermore, concerning the construction of structures for protection, there is a fear that the cost will place excessive burden on government finances (give consideration to countermeasure principle ②).

Through examining measures that utilize the forces of nature based on restoring and furthering coexistence with nature (giving consideration to countermeasure principle ④), forming technology that fits with administrative capabilities and local conditions, and securing the understanding and cooperation of citizens (giving consideration to countermeasure principle ③), it is necessary to adapt to the major negative impacts (threats) of climate change in the future.

The adaptation measures and mitigation measures examined in the Study are in accordance with the above principles and aim to mitigate the secondary damage (flooding, sediment disaster and drought) caused by the primary impacts (sea level rising and extreme meteorological phenomena) of climate change regarding existing and future vulnerability.

In examining the direction of adaptation measures and mitigation measures for each country, first the problems faced by each country will be arranged and common problems extracted. Also, the main support fields of donors will be stated and the direction of donor support will be confirmed.
The following table compiles the main impacts (problems) of vulnerability in the future and main support fields of donors according to the findings of the field surveys. The problems that are common to each country are also given.

[1] Examples of measures cited in the JICA Approach to Cooperation for Climate Change Adaptation Measures, each country's 2007 NAPA , the 4th IPCC Assessment Report and so on

Table 3-1.1 Main Impacts of Vulnerability in the Future and Support Fields of Donors

Country	Main Impacts (Problems) of Vulnerability in the Future		Main Support Fields of Donors
	Water Resources	Meteorological Observation and Disaster Prevention	
Nauru	- Advance of salinization - Worsening of droughts	- Submersion damage of coastal roads	- Integrated water resources management - Installation of rainwater tanks
Kiribati	- Advance of salinization - Worsening of droughts	- Damage to coastal facilities caused by high waves - Increased vulnerability to coastal erosion	- Integrated water resources management - Survey of water resources (ground water, etc.)
PNG	- Advance of salinization - Decline of river water and groundwater	- Increased water disasters - Increase of natural disaster damage due to inadequacy of meteorological observation and disaster information networks	- Integrated water resources management - Meteorological monitoring - Construction of mountain roads
Vanuatu	- Contamination by domestic wastewater due to inundation of water sources - Advance of salinization	- Increased water disasters - Increase in coastal damage at times of disasters - Increase of natural disaster damage due to inadequacy of meteorological observation and disaster information networks	- Integrated water resources management - Installation of water supply facilities - Disaster risk management - Home relocation - Meteorological monitoring
Samoa	- Instability of water supply - Water source turbidity	- Increase of water and sediment disasters - Traffic interruptions caused by inundation - Increase of natural disaster damage due to inadequacy of meteorological observation and disaster information networks	- Integrated water resources management - Meteorological monitoring - Impact survey
Tonga	- Worsening of droughts - Instability of water supply	- Increased inundation damage in capital cities (flood disasters) - Expansion of inundated areas during high tides - Increase of natural disaster damage due to inadequacy of meteorological observation and disaster information networks	- Mitigation of water supply risk - Provision of meteorological equipment and training of human resources
Solomon Islands	- Serious depletion of water resources - Advance of salinization	- Increased submersion damage of coastal roads - Frequent occurrence of flood and sediment disasters	- Integrated water resources management - Mitigation of water supply risk - Establishment of meteorological observation systems
		⇩	
Common problems	- Advance of salinization - Worsening of droughts - Instability of water supply	- Increase of water and sediment disasters - Traffic interruptions on coastal roads - Advance of coastal erosion - Inadequacy of meteorological observation and disaster information networks	- Integrated water resources management - Meteorological monitoring - Installation of meteorological observation equipment - Disaster risk management

Source: Prepared by the Study Team

Judging from the current direction of donor support indicated above, it can be seen that donors are engaged in salinization and drought countermeasures based on integrated water resources management. According to the hearings conducted with local governments and donors in the field surveys, this support comprises the securing of potable water through the installation of rainwater tanks and meteorological observation points, disaster countermeasures entailing the monitoring of natural disaster risks, compilation of plans by residents and reduction of damage, and implementation of fact-finding surveys geared to taking coastal erosion countermeasures.

3-2 Mechanism of Climate Change and Measures against it

3-2-1 Climate Change

(1) Mechanism of Climate Change

Global warming is caused by emission of greenhouse effect gas from human activity. Rising temperature will increase amount of vapor from the earth, and potential of atmosphere will become higher after absorbing vapor, which finally will cause abnormal weather. Relation between rising temperature and abnormal climate has been proved by increasing number of heavy rainfalls, heat waves, typhoons and hurricanes over the world.

(2) Observed Result of Climate Change and its Impact

Change of temperature and sea level were mentioned as shown below in the fourth IPCC Report, which was continuously published after February 2007.

1) Global warming is becoming obvious, which has been made clear by rising temperature of the ocean and the atmosphere, melting snow and ice over wide region, average rising sea level over the world.

2) Trend of rising temperature is 0.74 degree per 100 years during the past 100 years (1906- 2005).

3) Rising sea level over the world is 1.8mm per year in average since 1961, which was caused by heat expansion, melting of glacier and ice cap/sheet in the Polar Regions. Rising sea level is 3.1mm per year particularly since 1993.

4) Trend of rising sea level of the target countries until September of 2006 is 3.0mm in Vanuatu and 8.1mm in Tonga from the average sea level in 1992, 1993 and 1994. (Source: South Pacific Sea Level and Climate Monitoring Project by Australia)

5) There is high possibility that frequency of extreme heavy rainfall has increased in almost the entire regions.

6) There is high possibility that strength and frequency of extreme meteorological phenomenon and occurrence of high tide have been growing since 1975.

Table 3-2.1. Rising Sea Level of Target Countries

Recent short-term sea level trends SEAFRAME data through September 2006		
Location	Installation Date	Trend (mm/yr)
Fiji	Oct-92	+2.7
Kiribati	Dec-92	+6.0
Vanuatu	Jan-93	+3.0
Tonga	Jan-93	+8.1
Cook Islands	Feb-93	+3.1
Samoa	Feb-93	+6.7
Tuvalu	Mar-93	+5.8
Marshall Islands	May-93	+4.8
Nauru	Jul-93	+7.5
Solomon Islands	Jul-93	+6.3
PNG Manus	Sep-94	+7.7
FSM	Dec-01	+16.6

(Source : Meteorological Office of Australia)

(3) Expected Climate Change and its Impact

Expected fluctuation of temperature and sea level and its impact were summarized as shown below in the forth IPCC report.

- **Rising temperature and sea level**

1) The future average temperature at the end of twentieth century (rising temperature between 2090-2099 from that between 1980-1999) is 1.8 degree for the scenario assuming the social condition where environmental conservation is consistent with economic development, and 4.0 degree for the scenario assuming the social condition where gas emission will be the largest level.

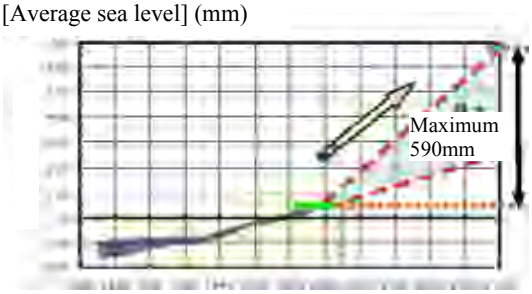
2) The future average sea level at the end of twentieth century (rising sea level between 2090-2099 from that between 1980-1999) is 0.18～0.38m for scenario assuming the smallest green house gas emission, and 0.26～0.59mfor scenario assuming the largest green house gas emission.

- **Growing strength of cyclone**

1) There is high possibility that frequency and strength of tropical depression will increase, and the other hand there is low possibility that occurrence of tropical depression will decrease. As shown in Table 3-2.2, number of tropical depression will increase 2.2 times as many as before, and the number classified into “category 4 and 5” will increase from 12% to 28% .

2) Route of tropical depression will shift toward the pole direction, and distribution of wind/ rainfall/temperature will also shift.

[Average sea level] (mm)



Source: Fourth IPCC Report

Figure 3.2-1 Average Sea Level

Table 3-2.2 Number of Tropical Depression and Ratio

Number and ratio of tropical depression of category 4 and 5				
Region	Period			
	1975-1989		1990-2004	
	Total	%	Total	%
Eastern Pacific	36	25	49	35
Western Pacific	85	25	116	41
Northern Atlantic	16	20	25	25
South west Pacific	10	12	22	28
Northern Indian	1	8	7	25
Southern Indian	23	18	50	34

Source: Fourth IPCC Report

- **Change of Rainfall**

1) There is high possibility that frequency of extremely high temperature, heat wave and heavy rainfall will be continuously growing.

2) There is high possibility that rainfall will increase in the high latitude area. On then other hand, rainfall will decrease in low latitude area (i.e. tropical area).

3) River discharge will increase in high latitude area, and will decrease in middle and low latitude area in global level by the middle of this century. They will suffer water shortage in semi-arid area by climate change.

3-2-2 Water Resources

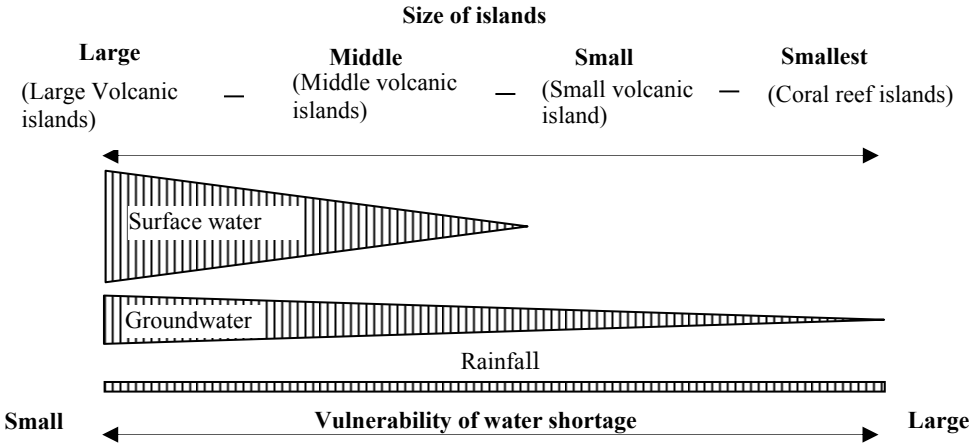
(1) Natural Characteristics of Water Shortage

Target countries have precipitation of more than 2,000mm/year. Generally speaking, countries in dry climate regions are apt to suffer water shortage. On the other hand, countries in tropical forest climate with much precipitation such as the target countries have a little possibility of drought. However, target countries consist of small islands that can not store much water within the territory, and after rainfall water will rapidly run-off to the surrounding sea. So capacity of water resources retention is small in the target countries, and water resource will be easily dry up after series of no rainy day. Such a natural condition will increase vulnerability of water shortage in the target countries.

(2) Relation between Island Size and Type of Available Water Resources

Target islands consist of various sizes of islands, the lager islands have higher capacity of water resources retention, and on the other hand, the smaller islands have smaller capacity of it. As shown in Figure 3-2.2, type of available water resources corresponds to size of islands. For example, surface water is available only in large islands. Groundwater is main water sources covering wide range of island size. Rainwater is only water sources for smallest islands because even groundwater can not be available in smallest islands. In coral reef islands, permeability of the ground is so high that entire rainfall will infiltrate into the ground and river can not be developed.

In each target countries, capital cities are usually located in the large island where surface water can be available for water supply. On the other hand within the same country, water sources are limited in smaller remote islands in the target countries. Type of water resources available in target countries are summarized in Table 3-2.3.



Source: Prepared by the Study Team

Figure 3-2.2 Relation between Size of Islands and Type of Water Resources Available

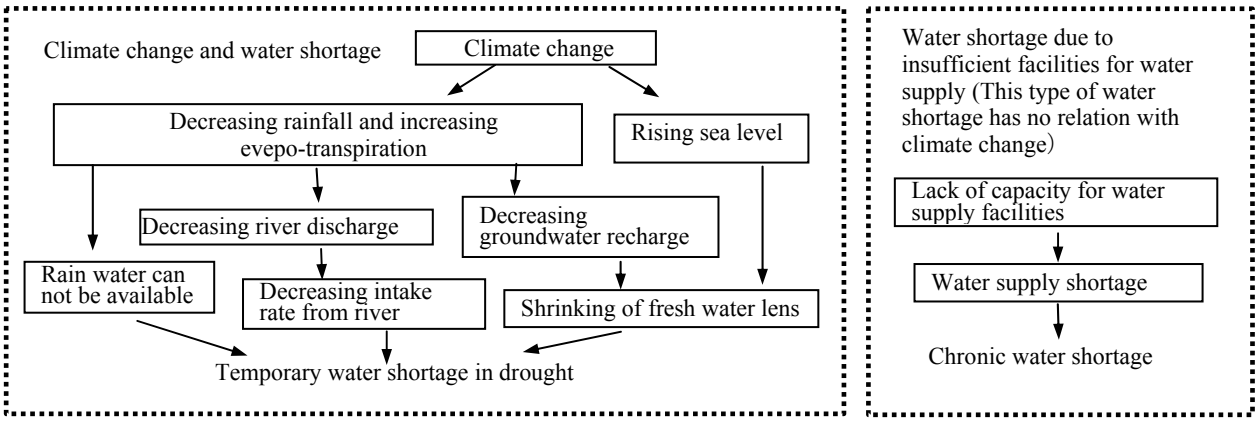
Table 3-2.3 Type of Available Water Resources in Target Countries

Country	Type of Available water sources	Size of islands	Water resources
Nauru	①desalinized sea water, ②rain water, ③groundwater	Small coral reef islands	Water resources is poor
Kiribati	①groundwater, ②rain water	Small coral reef islands	
PNG	①Surface water, ②groundwater, ③rain water	Large volcanic islands－small coral reef islands	Water resource is rich in large islands and poor in small islands
Vanuatu	①surface water, ②groundwater, ③rain water	Middle volcanic islands－small coral reef islands	
Tonga	①groundwater, ②rain water, ③surface water	Small volcanic islands － small coral reef islands	
Samoa	①surface water, ②groundwater, ③rain water	Middle volcanic islands	Water resources is relatively rich
Solomon Islands	①surface water, ②groundwater, ③rain water	Large volcanic islands－small coral reef islands	Water resource is rich in large islands and poor in small islands

Source: Prepared by the Study Team

(3) Cause of Water Shortage

Water shortage will occur following mechanism as shown in Figure 3-2.3.



Source: Prepared by the Study Team

Figure 3-2.3 Mechanism of Water Shortage Occurrence

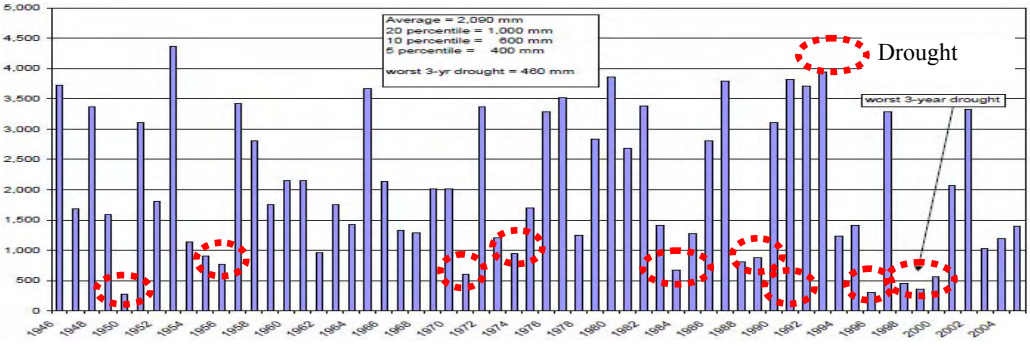
Cause of water shortage due to climate change is pointed out as i) decreasing precipitation and ii) rising sea level. As for decreasing precipitation, long term trend of decreasing precipitation was definitely

obvious, and droughts were more frequently taking place. Furthermore, it is widely admitted that rising sea level is caused by climate change. Mechanism of shrinking fresh water lens, by decreasing precipitation (drought) and by rising sea level, is shown in Figure3-2.5.

On the other hand, it is pointed out that insufficient facilities for water supply will also cause water shortage, though which has no relation with climate change. However it should not be overlooked that insufficient facilities will make water supply more vulnerable against climate change.

(4) Degree and Frequency of Water Shortage

As mentioned in Chapter two of this report, extremely low precipitation statistically took place three times (i.e. three years) every ten years in target countries. For example, annual precipitation of Nauru is shown in Figure 3-2.4. Average annual precipitation of Nauru is 2,000mm. As shown in Figure 3-2.4, in drought year precipitation was drastically decreased to 1/10 – 1/2 of the average precipitation. In such period, impact by drought was serious. Therefore, it can be said that there is strong relation between annual precipitation and water shortage according to the past example.



Source: SOPAC

Figure 3-2.4 Annual Precipitation of Nauru

(5) Water Demand and Measures to Water Shortage

Water demands are different country by country. Furthermore, water demand is also different between urban area and rural area within one country. In target countries, water demand depends on i) fresh water development potential, ii) water supply method, iii) price of water. For example, water demand in small remote islands depending on rain water is small, such as 20-50ℓ/person/day. On the other hand, water demand of large volcanic islands depending on gravity piped water supply system from river water is large, such as 600ℓ/person/day. It was reported that standard water demand in target countries is 50-150ℓ/person/day[1]. Water demand of urban area is larger than that of rural area because of much opportunity for water use in urban area. Example of standard water demands in target countries is shown in Table 3-2.4.

Table 3-2.4 Standard Water Use and Water Sources of Target Countries

Country	Water use (ℓ/person/day)	Type of water sources (%)		
		River	Ground water	Rain water
Kiribati	40 (1999)	0	100	
Nauru	24 (2009)[1)]	0	100	
PNG	600 (1999)	90	5	5
Solomon Islands	250 (1999)	85	10	5
Tonga	102 (1999)	30	60	10
Vanuatu	—	65	20	15
Samoa	600 (1999)	55	40	5

Note-1) this value was estimated in this study.
Source: Effect of forestry activities on surface water quality in the Pacific region: a case study of the Rewas River catchment, Fiji Islands, SOPAC

[1] Toward sustainable water management in the pacific, Theme 1 overview report water resources management, Tony Falkland, 2002

As explained repeatedly, river water, groundwater and rain water are available for water sources in target countries. Water use other than domestic use, such as industrial and agricultural use, is strictly limited due to scarcity of water resources in target islands, except in large volcanic islands having large water resources. It is said that amount of water necessary for human drinking is only 2ℓ/person/day. In drought time water use other than drinking is restricted to securer drinking water. Even groundwater in coastal area, which usually suffers salinization, is also used for drinking as long as concentration of salinity in groundwater is low. Measures against water shortage are shown in Table 3-2.5.

Table 3-2.5 Measures against Water Shortage by Water Sources

	Measures against drought		Note	Country applicable of measures
For water sources	River	• To increase capacity of water intake facilities • To increase capacity of water reservation facilities	Water intake and water reservoir facilities should be increased for compensation of decreasing river discharge.	Vanuatu, Samoa, PNG, Solomon Islands
	Groundwater	Measures against Stalinization	See Figure 3-2.6.	Entire target countries
	Rain water	To increase capacity of rain water tank.	There is limitation in tank capacity.	Entire Target countries
The other	Desalinization		Desalinization should be applied where fresh water sources are extremely limited.	Nauru, Kiribati
	Emergency water transport		Emergency water transport is limited to small remote islands.	Entire target countries
	Rationing and saving water		Understanding and cooperation of consumers is necessary.	Entire target countries

Source: Prepared by the Study Team

Concerning water supply during prolonged drought, rain water is most vulnerable, and river water follow it. Groundwater is the less vulnerable than rain water and surface water. Rain water can not be used during long drought because water tank will soon become empty. River water will also disappear after prolonged drought, if it exceeds capacity to keep water in a river basin. The capacity of a river basin to keep water is proportional to size of a river basin. On the other hand, groundwater is stored in aquifer, and it will not easily dry up even after prolonged drought. Furthermore, considering advantage of groundwater that is available regardless of island size, it can be proposed to promote groundwater use for measures against water shortage. However, groundwater needs some measures against salinization.

(6) Measures against Salinization

Measures against salinization of groundwater can be implemented by controlling draw-down of groundwater level of fresh water lens. Type of the measures is classified as shown in Figure 3-2.6, which can be applied for target countries in considering technical points explained below:

- Basic principle of measure against salinization is to preserve fresh water lens. For this propose, method for controlling rain water run-off into the sea is effective.
- Under ground dam is effective to prevent salinization of groundwater by stopping sea water intrusion. Underground dam site needs geological condition below:
  - ― There must be impermeable basement rocks under aquifer of coral reef limestone. Foundation of dam body should be placed on the impermeable basement rocks.
  - ― Underground dam site should be located where impermeable basement rock form under ground valley.

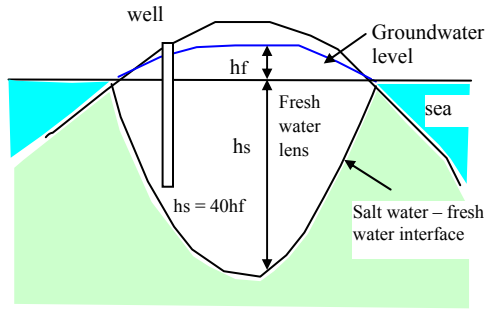
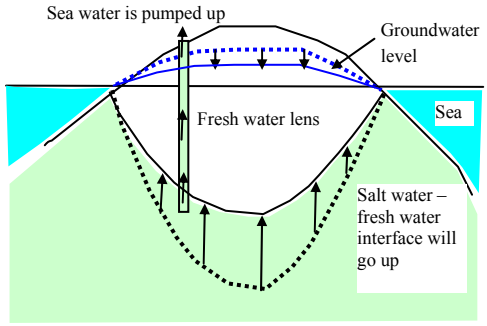
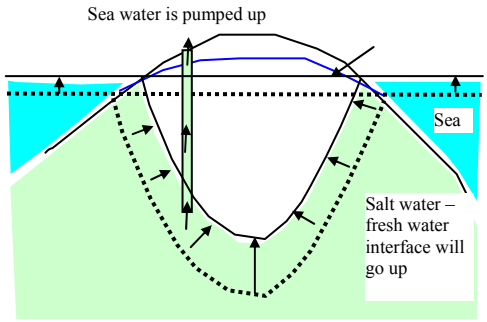
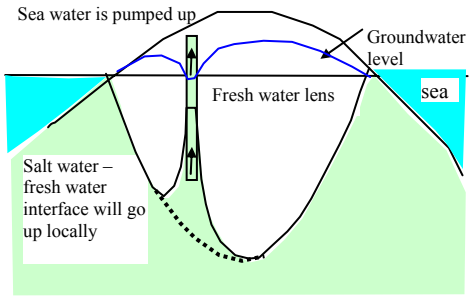
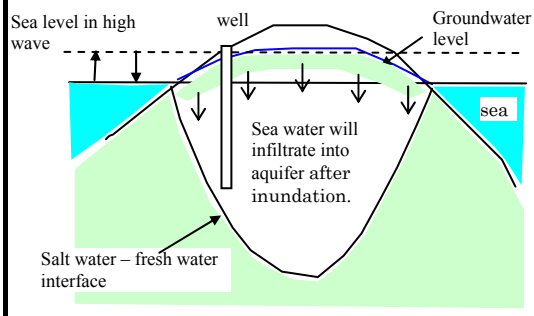
Foundation of an underground dam body should be on impermeable rocks. Underground dam located in underground valley can store groundwater efficiently. From above view point, suitable site for underground dam can not be found in low lying island such as Kiribati and Nauru, where impermeable basement rocks are distributed considerably deep under coral reef limestone. On the other hand, suitable site for underground dam can be found in countries such as PNG, Solomon Islands, Samoa and Vanuatu, where volcanic rocks are distributed under coral reef limestone in shallow part of the ground.

- There are many common factors in topography, geology and hydrogeology among target countries in terms of planning and designing measures against Stalinization. Therefore, it is possible to establish standard methods of geological investigation/analysis, standard design applicable to target countries.

- Size of fresh water lens is not constant, always expanding and shrinking. Aquifer along the sea coast was sometimes intruded by the sea water during the past drought. Generally speaking, it will take several years for aquifer to recover to original state, once it is intruded by the sea water. Most of the aquifers along the coast are already suffering from Stalinization to some extent. Wells with high Stalinization should be carefully treated: for example those wells with electric conductivity of more than 5,000μS/cm should be abandoned, and new wells should be drilled or dug inland area where sea water intrusion does not reach.

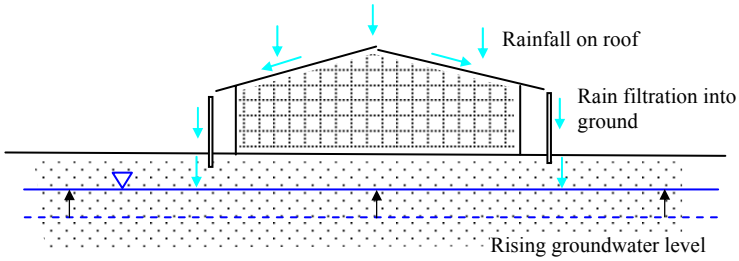
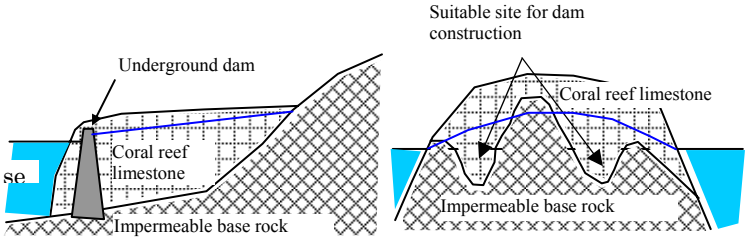
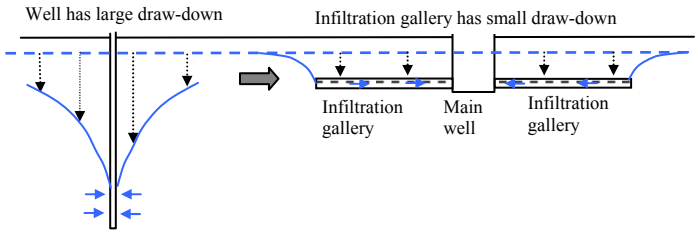
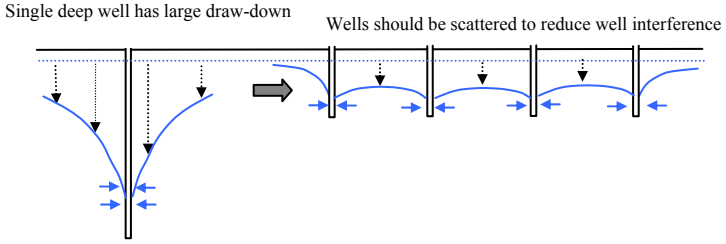
(7) Measure for water contamination

Amount of domestic effluent is increasing with growing water consumption with growing population and economic development of the target countries, which results in water resources contamination. Water contamination above will give impact to water resources. River water and groundwater are very vulnerable to contamination by domestic effluent, thus urban effluent will give serious impact to water resources. Groundwater in coastal aquifer is suffering from contamination by domestic effluent, as well as Stalinization. Therefore, measure against contamination is necessary for groundwater in the coastal area as well as measures against Stalinization.

Condition of fresh water lens	Explanation
	**<Before Stalinization>** Thickness of fresh water lens is (hf+hs) with relation of hs=40hf (Ghyben-Herzberg's law). Consequently, thickness of fresh water lens is determined by groundwater level (hf).
	**<Mechanism of shrinking fresh water lens (1): Decreasing precipitation>** Groundwater recharge will become small by decreasing precipitation. As a result, groundwater level will go down. By this, both hf and hs become small (from relation of hs=40hf). As a result, salt water – fresh water interface will go up. Consequently, fresh water lens will shrink.
	**<Mechanism of shrinking fresh water lens (2): Rising sea level>** Salt water – fresh water interface will go up by rising sea level. Coastal line will shift toward inland area. As a result, island area will become small, and thus groundwater recharge will also become small. It results in shrinking fresh water lens. It will cause impact on groundwater use because salt water – fresh water interface will go up and finally intrude into well.
	**<Mechanism of shrinking fresh water lens (3): Over-pumping>** Fresh water will become saline when salt water – fresh water interface goes up and intrude into a well by over pumping, which will cause extremely large draw-down of groundwater level around a well.
	**<Mechanism of shrinking fresh water lens (4): Sea water inundation>** Sea water will infiltrate into aquifers after inundation by high wave.

Source: Prepared by the Study Team

Figure 3-2.5 Mechanism of Stalinization

Type of measures	Content of measure	Countries for application
(1) Promoting groundwater recharge	Salinization will be prevented by promoting groundwater recharge into the ground to raise groundwater level.  	• Nauru • Kiribati
(2) Underground dam	Underground dam will prevent both ineffective groundwater run-off into the sea and sea water intrusion into inland aquifer.  	• PNG • Solomon Islands • Samoa • Vanuatu
(3) Improving water Intake facilities	Optimum groundwater intake facilities instead of wells, such as infiltration gallery, will make groundwater level draw-down smaller.  	Entire countries
(4) Scattering wells	Several shallow wells being scattered in wide area, instead of single deep well, will minimize draw-down of groundwater level.  	Entire countries

Source: Prepared by the Study Team

Figure 3-2.6 Measure against Stalinization

3-2-3 Impact to Meteorological Observation and Disaster Prevention

By effect of global warming, sea level will be rinsing, cyclone will happen more frequently and become stronger, and precipitation will be more changeable. Phenomenon above will increase external force as impact in terms of disaster prevention as explained below:

(1) Increasing Impact by High Tide and Coastal Erosion

Rising sea level is influenced by natural factors such as i) fluctuation of atmospheric circulation during tens of years, ii) melting of glaciers and Antarctic ices, iii) El Nino and iv) change of ocean current for 10 years duration. Therefore, long term observation more than 20 years duration is required to know behavior of rising sea level with high accuracy place by place, which is still under investigation. Rising sea level will make coastal area more dangerous by inundation, by high tide with strong wind, by heavy rainfall and erosion, threatening social infrastructure, houses and facilities necessary for the islands. To make shore slope stable, the shoreline will recede more distance than expected by only effect of rising sea level. For example, 1m of rising sea level will cause 100m of receding shoreline and give impact to function of facilities along the coast. Impact of the target countries are summarized as shown in Table 3-2.6.

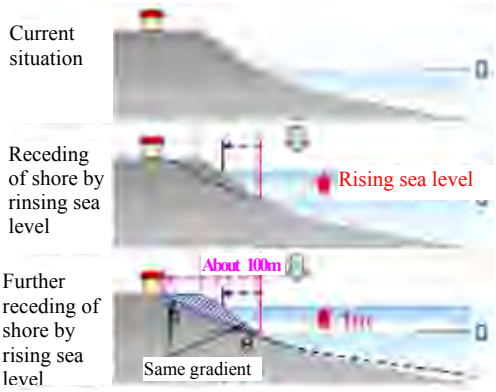


Figure 3-2.7 Rising sea Level and Retreating Coastline

(Source: River Dep. of Min. of Land and Transportation of Japan)

Table 3-2.6 Natural Disaster by Rising Sea Level

Countries	Natural condition	Type of Disaster
Nauru	Small coral reef island	Costal erosion
Kiribati	Small coral island	Costal erosion, High tide
PNG	Large volcanic islands – small coral islands	High tide
Vanuatu	Medium volcanic island – small coral reef islands	Costal erosion, high tide
Tonga	Small volcanic islands- small coral reef islands	Costal erosion, high tide
Samoa	Medium volcanic islands	High tide
Solomon islands	Large volcanic islands- small coral reef islands	Costal erosion

Source: Prepared by the Study Team

(2) Increasing Flood

IPPC forth report, which was compiled with grovel view point, suggests that there is high possibility of extreme strong rainfall. There is high possibility that frequency and strength of tropical atmospheric depression will increase. And its changing rote toward the pole will increase mount of flooding water. As a result, a safety factor of flood control by the current facilities will decrease and danger of inundation and flooding will increase. Five countries of this Study, except Nauru and Kiribati as shown in Table 3-2.7, have possibility of impact from flooding with their poor drainage system.

Table 3-2.7 Type of Natural Disaster

Countries	Type of disaster
PNG	Flood and drainage
Vanuatu	Flood and drainage
Tonga	Drainage
Samoa	Drainage
Solomon islands	Drainage

Source: Prepared by the Study Team

It is necessary to predict fluctuation of precipitation by climate change. It can be analyzed based on distribution of atmospheric pressure, employing down-scaling model (densely subdivided-space model with high resolution system), though it is still in study stage.

(3) Increasing Sediment Disaster

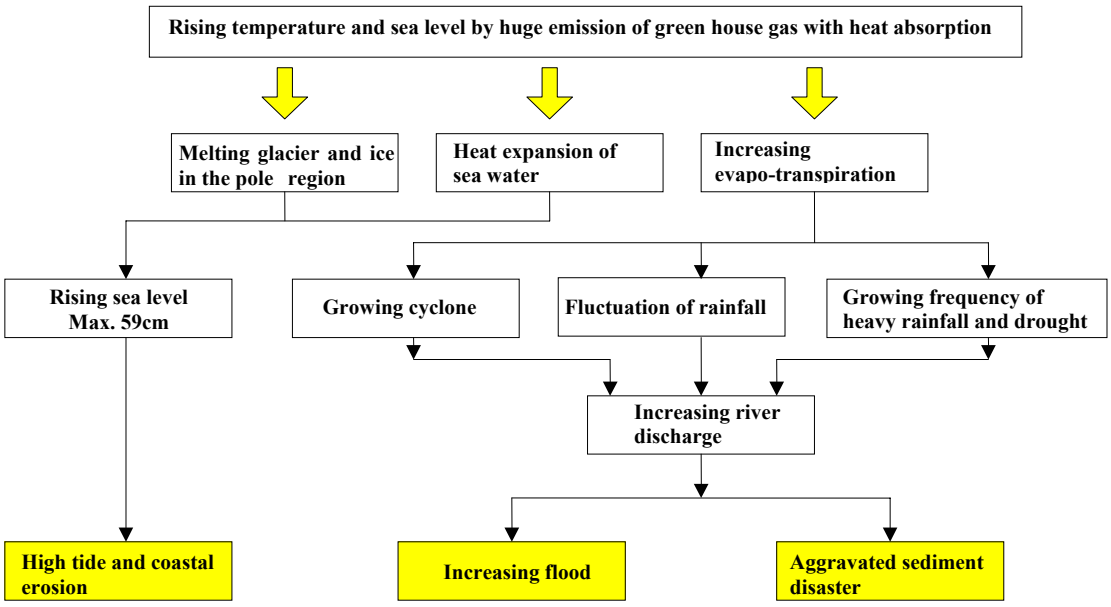
Distribution of rainfall will be changed in terms of time and space by climate change. Furthermore, both rainfall strength for a short period and total amount of rainfall will crease, which will act as induced factor of sediment disaster. By impact from the climate change, it is predicted that sediment disaster will happen more frequently and occur at different season, increasing scale of disaster. As a result, it is assumed that area of disaster will expand to area out of expectation. Especially by rainfall larger than predicted, there will be serious sediment disaster where there used to be only small rainfall. As a result of change in disaster season, interval from the beginning of rainfall until outbreak of collapse will be shortened, and time necessary for evacuation will also shorten. Increasing sediment discharge will induce flooding of huge amount of sands and gravels in the middle/down-stream area of the river. Sediment disaster will worsen in five countries as listed below:

Table 3-2.8 Countries and Area with more Serious Sedimentation Disaster

Country	Area
PNG	Highland, Morobe
Vanuatu	Efate, espiritu santo etc.
Samoa	'Upolu, Savai'i
Tonga	Vava'u
Solomon Islands	Gudalcanal (Sasaa area)

Source: Prepared by the Study Team

Change of natural condition by global warming and impact to disaster prevention is summarized in Figure 3-2.8.



Source: Prepared by the Study Team

Figure 3-2.8 Change of Natural Condition and Impact to Disaster Prevention by Global Warming

(4) Adequate Adaptation Measures

Phenomena having impact to disaster prevention is classified into i) change of rainfall, ii) expansion of tropical atmospheric depression and iii) increasing temperature. Risk of flood and sedimentation disaster will increase in the area where rainfall increases. Furthermore, expansion of tropical atmospheric depression and change of cyclone route will give more damage by flood resulting from increasing wind-speed and total rainfall. It is expected that risk of coastal erosion, damage by high tide and flood along the coastal area will increase by rising sea level.

Measures against current disaster will contribute to mitigate damage that will happen in the future by climate change. Therefore, it is effective to formulate adaptation plan in advance carefully.

1) As for coastal area, construction works such as revetment, detached breakwater, jetty and beach reshaping are effective to mitigate impact by coastal erosion and high tide. On the other hand, to mitigate damage by flood of rivers, construction works such as embankment, training dike, spur dyke, retarding basin, river bottom excavation are effective. At the same time, soft measures are also necessary against increasing danger of the above disaster. Establishment of warning and evacuation system is recommendable by sharing common information between responsible organizations and residents, based on sign and initial information of disasters occurrence, by the use of the latest information technology.

2) To mitigate sediment disaster, restraint works against sediment disaster by construction measures such as sabo dam, and non-construction measures such as warning and evacuation activity after detecting are with high risk of sediment disaster are effective and now under implementation..

3) Formulation of master plan, prediction of assumed disaster by climate change and support for designing structures taking account of disaster risk can be recommended.

4) For human resources development, activity for capacity development for communities and responsible organizations is expected to improve capacity to deal increasing risk (i.e. formulation of risk management plan). Adaptation measures are classified and example of adaptation measures in Japan are shown in Figure 3-2.9

Table 3-2.9 List of Adaptation Measures

【Disaster Prevention in Coastal Area】 - Structural measures such as revetment, detached breakwater, jetty and beach reshaping, cyclone shelter for measures against coastal erosion and high tide and flood protection - Non structural measures such as warning (including meteorological observation) system, evacuation activity.
【Disaster Prevention of River】 - Structural measures against flood such as embankment, training dike, spur dyke, retarding basin, river bottom excavation, drainage pumping, flood protection - Non structural measures warning system, evacuation ac non structural measures such as activity.
【Disaster Prevention of Sediment Disaster】 - Installation of sabo dam and restraint works against sediment disaster - Support for formulation of non-structural measures such as warning and evacuation system
【Formulation of Disaster Prevention Plan】 Formulation of disaster prevention master plan and prediction of assumed disaster by climate change, support for construction design considering increasing risk.
【Human Resources Development】 - Support for capacity building for communities and responsible organizations - Training program for meteorological observation

Source: Prepared by the Study Team

Among proposed adaptation measure, as for area vulnerable to high tide such as Tongtap Island, combination measures by construction of revetment and risk management (compiling hazard map of inundated area and formulating evacuation activity plan) will be effective. Combination of different adaptation measures will be more effective than single measure. Furthermore, strategy should be examined including protection measures, adaptation measures (such as construction of elevated floored houses), and withdrawal measures (such as shifting to high elevation lands from the current low lying residential area).

5) As for meteorological observation, target countries except for Nauru are involved in member of World Meteorological Organization (WMO). WMO is providing satellite photographs and data from Global Ocean Observation System (GOOS) and Information of Global Ocean Service System (IGOSS), to meteorological offices of member countries. It is recommended to provide data from above WMO system urgently to remote islands and communities as adaptation measures. Participation in training by JICA and WMO for meteorological observation is also recommended as human resources development.

Jetty was constructed against coastal erosion in tourism area (Indonesia, Japanese loan project)

Radar for metrological observation (Bangladesh, Japanese Grant Aid project)

Figure 3-2.9 Example of Adaptation Measures by Japan

6) For support of designing for structural measures against high tide, rising embankment made of concrete, should be implemented when it is renewed, considering effect of increasing external force in case of their renewal in case of their renewal to reduce frequency of inundation (formulation of design standard).

7) In actual implementation, based on study progress on rising sea level and growing strength of cyclone, rising embankment should be implemented step by step as shown in Figure 3-2.10.

- As I stage, current rising sea level should be taken into account.
- As II stage, amount of rising sea level, which is extrapolated or predicted considering durable life of facilities, will be taken into account, adding to the existing rising sea level.
- As III stage, adding to procedure in the II stage, rising sea level of high tide by growing cyclone will be taken into account for construction work of rising embankment. Depending on importance of background area, it is crucial to take measures as early as possible considering way of methods of stage II and stage III.

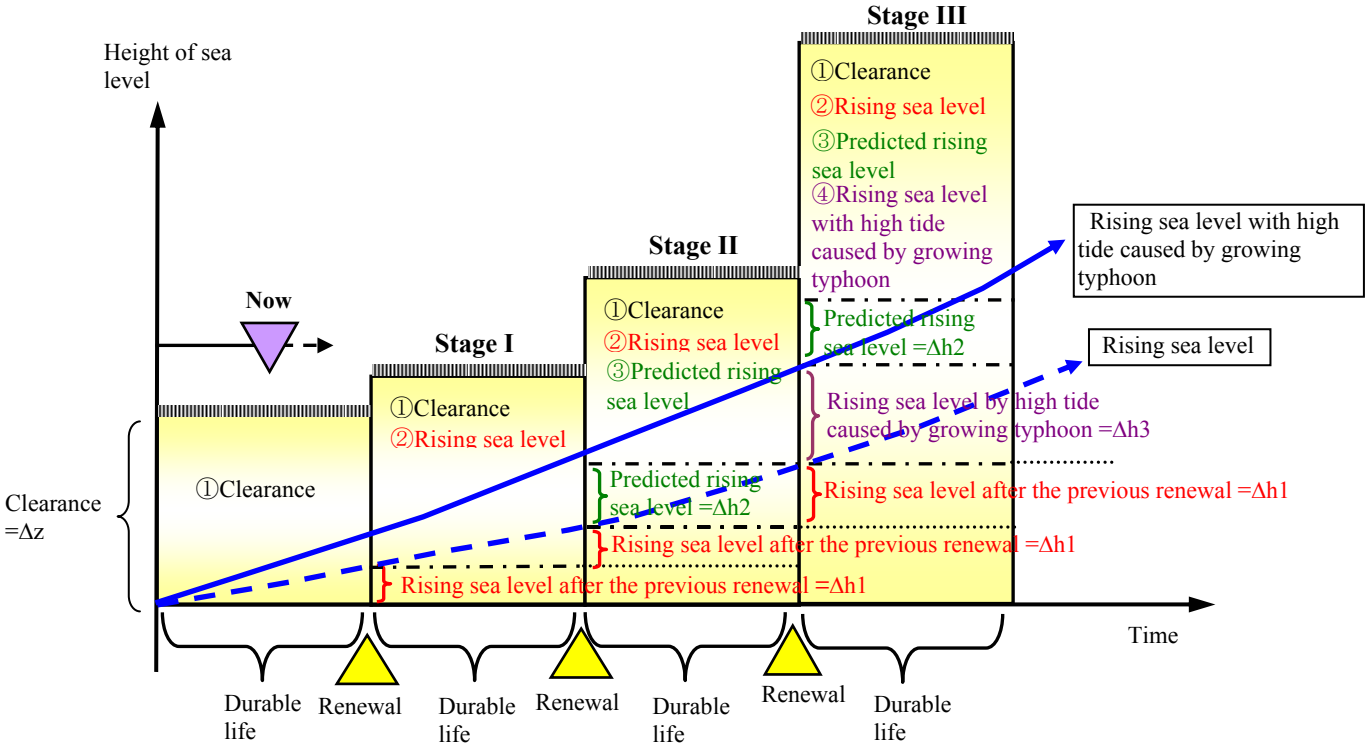


Figure 3-2.10 Formulation of criteria for Rising Embankment against High Tide (Min. Land, Infrastructure, Transport and Tourism of Japan)

Furthermore, it is necessary to examine design methods considering external forces acting to structures caused by rising sea level.

8) It is necessary to make clear vulnerability in targets countries, estimating risk of impact from flooding disaster by climate change under future social and environmental condition. As for flood disaster, risk of flood should be analyzed assuming various floods with different scale, according to analyzed flooding type in the river basins. Establishment of hazard map is one of important adaptation method which reflects capacity against disaster by construction works and evacuation activity.

   It is important to analyze and examine change of landscape and coastal line though monitoring work. Such topographical changes will be caused by change in flow condition and sediment discharge condition by climate change. Monitoring of river flow and coastal environment including coastal line should be continued through data collection of remote sensing and accumulation of map information, as well as data of climate change for a long period time.

3-3 Conclusion - Direction of Adaptation Measures and Mitigation Measures by Country

Based on the above findings, the direction of support measures that are common to the entire target area can be summarized into the following three points. The reasons behind their selection are also described.

i. Development of alternative water sources and introduction of appropriate water use: Mitigate water shortages through securing new water sources and appropriately using existing water sources, in order to address the salinization of water and water supply shortages caused by climate change.

<Reason>
All the countries are experiencing widespread water shortages and drought problems, and this is an important support field from the perspective of human security. Accordingly, various donors are implementing salinization countermeasures and drought countermeasures. In particular, installation of rainwater tanks and so on helps alleviate water shortages through realizing the efficient intake of rainwater in the countries concerned.

However, since the target area is so wide and the targets are so numerous, many areas still haven't been addressed and donors will need to continue implementing salinization countermeasures and drought countermeasures.

Meanwhile, based on its experiences of remote islands development, Japan possesses underground water storage and freshwater lens conservation technology, specifically concerning the physical prospecting of groundwater and installation of underground dams, etc.

These Japanese technological characteristics can be utilized to alleviate water shortages in Pacific island nations through installing underground storage facilities for efficiently securing rainwater and making appropriate use of existing water resources. Through such measures, drastic improvements can be expected in some parts of the Pacific.

ii. Meteorological observation capacity building relating to climate change:
Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change; install meteorological observation networks, and improve area and local meteorological forecasting capacity.

<Reason>
Australia and the United States have taken the initiative in installing meteorological observation equipment, establishing observation points and monitoring weather conditions for climate change. Japan is also contributing to improving meteorological forecasting capacity in the Pacific nations through the Meteorological Forecasting Capacity Building and Networking project currently being mainly implemented in Fiji (September 2009 to March 2010).

However, in order to appropriately monitor future conditions of climate change and forecast and respond to natural disasters caused by extreme meteorological phenomena in future, it will be necessary to improve localized meteorological forecasting technology. Accordingly, in addition

to existing activities, it will be necessary to cooperate in improving meteorological capacity while taking climate change into account.

Meanwhile, the meteorological observation equipment supply projects so far conducted by other donors have focused on expanding observation points and installing observation systems in the countries concerned, however, the resulting observation data cannot be shared among all member nations on the World Meteorological Organization (WMO) network.

Accordingly, an important direction for support will be to construct an observation network and interfaces that enable the observation data in each country to be shared on the WMO network. Doing this will prevent the overlapping of support activities with existing donors and facilitate collaboration with other donors. AusAID and WMO are implementing activities below for human resources development.

①Enhanced Application of Climate Prediction in Pacific Island Countries Project: AusAID

The Project, starting from 2002, aims to strengthen the capacity of Pacific island countries in climate prediction. It includes Fiji, Tonga, Cook Islands, Vanuatu, Tuvalu, Solomon Is, Kiribati and Niue. The Project develops capacity of National Meteorological Services through the provision and tailoring of climate prediction software and training in its prudent use. Senior representatives from industry and government engaged in climate sensitive activities will receive training in the causes of climate variability, and in how to interpret and make use of climate probability forecast information

②Technical Cooperation Programme: WMO

The Programme promotes international cooperation in capacity building to ensure Members countries have the pertinent capacity and resources needed, particularly to bridge the gap between the levels by expand the knowledge and information on meteorology, hydrology and others to the Members. The Programme also assists Members to support technical assistance and the equipment necessary for meteorological and hydrological services for their countries. The Programme is collaborative development under UNDP, UNEP, GEF and other regional development banks.

Proposed capacity building is concentrated on the local rainfall prediction technology necessary for early flood forecasting. Japan's technology and experience of rainfall prediction in Typhoon, seasonal rainfall early in summer and autumnal rain front can be applied in Oceanic Island countries and is supplementary to the capacity building on basic knowledge and technology of meteorology and hydrology supported by WMO and AusAID. The climate prediction software with the equipment supply supported by AusAID shall be calibrated, and the capacity building of the software calibration is developed by the detailed lesson in the capacity building of Japanese Senior Voluntaries. The systematic technical cooperation programme with WMO and AusAID will make a high performance.

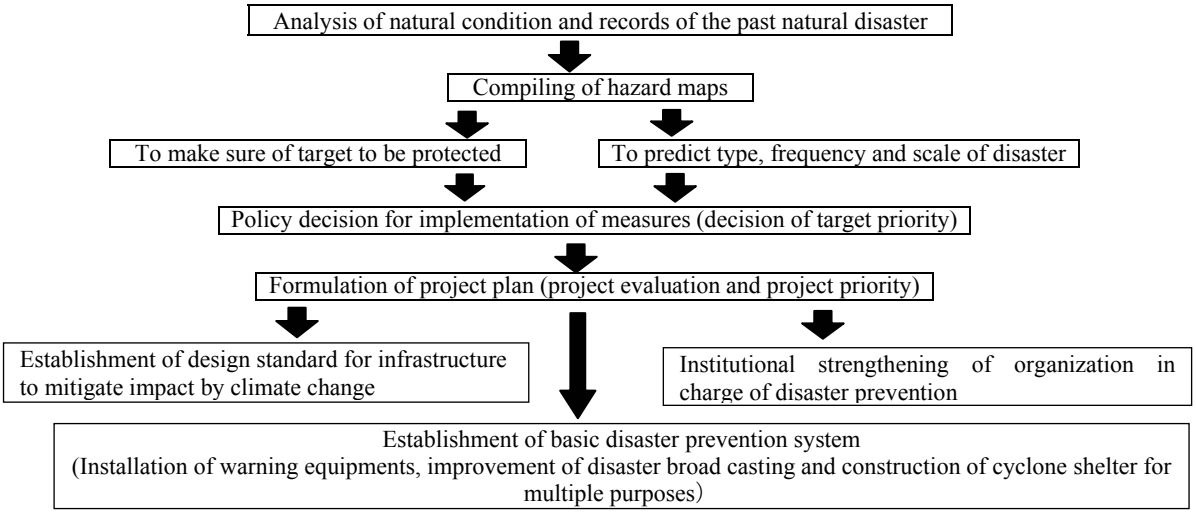
iii. Climate change risk management: Manage risks linked to climate change in order to mitigate the impacts of climate change.

<Reason>

Climate change increases the risk of natural disaster and imparts a major impact on the lives of residents. It also has the potential to destroy socioeconomic infrastructure and cause major economic damage to the countries concerned. However, judging from the scale of the economies in the target countries and technical level for disaster prevention, it is difficult to implement hard countermeasures with large-scale as same as the advanced nations. Therefore, it is desirable to implement efficient measures to mitigate impact of climate change by employing risk management procedure.

As shown in Figure 3-3.1, at first step in risk management procedure, natural condition and records of the past disasters will be totally analyzed to compile disaster hazard map, and targets to be protected from natural disaster will be identified according to type, frequency and scale of disaster. Based on the result of this analysis, planning policy and priority of the targets to be

protected can be examined. Then in the next step, individual measures (soft and hard measures) can be proposed. After project evaluation on its effect, each project will be implemented following its priority.



Source: Prepared by the Study Team

Figure 3-3.1 Method of Risk Management

Direction of support by government of Japan was proposed in this Study based on initial analysis employing risk management procedure. Before implementation of individual project, it is necessary to establish institutional basement following risk management procedure in each country. Technical assistance for risk management should be implemented as well as technical assistance for each project.

We have compiled country-separate lists indicating countermeasures under these three directions of support classified according to degree of urgency into short term (support that should be implemented in 2~3 years) and medium to long term (support that should be implemented over around 5 years). Also, these lists state wide area applicability of the adaptation measures and mitigation measures as described in Section 3-2-2. The following sections describe this together with the features of support, etc. in each country.

3-4 Country-Separate Adaptation Measures and Mitigation Measures

3-4-1 Nauru

(1) Features of Support in Nauru

As was mentioned in the description of current conditions in Chapter 2, the most urgent problem facing Nauru concerns how it will respond to water shortages. Nauru has extreme vulnerability to dry weather and droughts caused by climate change. Rainwater tanks are being installed on the community level under assistance from Japan and other donors, however, these do not constitute fundamental improvements. The Government of Nauru also regards dry weather and drought countermeasures to be its most important area concerning climate change.

On the other hand, since Nauru is not impacted by cyclones, disasters are limited in nature. Due to landfilling at the airport and construction of fishing ports, localized coastal erosion is occurring and traffic interruptions are arising on parts of coastal roads due to the overtopping of waves. Concerning coastal erosion, SOPAC has surveyed the situation and has already compiled basic data from topographical surveying, etc.

Concerning the government response, as was described in Chapter 2, the Disaster Management Committee has been organized, evacuation plans have been compiled and evacuation has already been executed on the occasion of a tsunami. Also, a disaster management plan is currently being formulated. Moreover, concerning climate change, a national committee has been organized, and the Department of

Commerce, Industry and Environment is taking the initiative in examining adaptation measures in accordance with the NAPA.

In view of these conditions, there are limited openings for Japanese cooperation concerning disaster prevention and coastal erosion, and the needs of the local side are limited to meteorological observation and enlightenment activities.

The following paragraphs describe specific countermeasures under each direction of support in Nauru, while Table 3-4.1 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Integrated Water Resources Management

i. Underground storage of rainwater

Taking into account the large fluctuations in annual rainfall, operating condition of desalinization equipment and the sanitary state of rainwater tanks, the underground storage, etc. of rainwater is deemed to be the most efficient approach to dealing with droughts in Nauru.

Since the groundwater occurrence area is a phosphate mining district under government management, it will be easy to implement countermeasures. Moreover, the Nauru government has already implemented hydrological and geological surveys in the target area and can utilize the findings from these in projects. Possible approaches to underground storage are promotion of rainwater recharging and construction of underground dams. Japan has abundant experience in these technologies and can fully utilize these technological characteristics. At the same time, this is thought to be the most important issue facing Nauru for ensuring human security.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

Concerning meteorological observation, Nauru has no meteorological forecasters, it cannot conduct its own analysis of meteorological data, and data need to be directly transmitted to equipment donors for analysis. Accordingly, Nauru does not have the capability to implement meteorological forecasting. In order to examine the measures that can be adopted by the government with respect to droughts and so on, it is necessary to train meteorological forecasters domestically in Nauru. Currently, Nauru obtains forecasts from the meteorological observation station in Fiji, however, since these are wide area forecasts, it is necessary to improve technology and train forecasters in order to conduct forecasts that consider local characteristics and target mainly dry weather in Nauru.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Compilation of disaster (drought) countermeasures criteria

Concerning dry weather and droughts, it is possible that rainfall will decline as a result of climate change in future, and compilation of disaster (dry weather and drought) criteria based on water restrictions, etc. linked to forecasting can be considered. This item has not been raised by other support agencies, however, it can prove useful for mitigating dry weather and drought risks and is an area where Japanese successful experiences can be utilized.

Furthermore, dry weather and drought countermeasures are raised as potential areas of cooperation in the other Study nations, although the contents are securing of alternative water sources and introduction of appropriate water use. Thus, from the viewpoint of risk management, the outputs here can be deployed to other countries that possess similar conditions.

ii. Dissemination and enlightenment activities

Raising the knowledge of residents concerning the various impacts of climate change promotes changed awareness among citizens and has the potential to bring forth autonomous dry weather and drought countermeasures on the community level. In Nauru, where community ties are strong,

since climate change risk management becomes a means of self defense, it lowers risks at times of dry weather.

iii. Port construction

Amidst growing vulnerability and risk concerning dry weather and droughts caused by climate change, the stable supply of commodities is essential for ensuring human security. Since the existing port facilities cannot receive large transport ships, freighters have to dock and unload out at sea, and these activities are hindered when high waves occur. Since ships have to wait out at sea until the waves calm down, this has an economic impact. Accordingly, construction of facilities that will enable ships to enter and dock at port is an important issue that needs to be addressed in order to secure the stable supply of necessary goods.

When implementing port construction, it will also be necessary to verify validity including environmental impact assessment.

Table 3-4.1 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Nauru

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1	Integrated water resources management	Mitigate salinization of groundwater and drought water shortages arising from climate change, and support the realization of human security.	Short term	Underground storage of rainwater	Utilizing the findings of the groundwater assessment conducted by the NRC, implement efficient groundwater storage. At the same time, implement the technology transfer required for maintaining underground storage.	A	
2	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	A	○
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Compilation of disaster (drought) countermeasures criteria	Assess the impacts of disasters and compile the policy of disaster countermeasures. As a pilot area, select Nauru, where droughts have become a regular occurrence, and disseminate the compiled outcome to other countries and areas that have a similar environment.	A	△
			Medium to long term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change in order to enhance response capability at times of drought, etc.	B	
			Short term	Port construction	Amidst growing vulnerability and risk concerning dry weather and droughts caused by climate change, implement port construction able to respond to changes in meteorological and ocean conditions, in order to secure the stable supply of necessary goods. However, when examining potential for implementation under grant aid, it is necessary to conduct verification of validity including environmental impact assessment.	C	

3-4-2 Kiribati

(1) Features of Support in Kiribati

Climate change adaptation measures in Kiribati are consolidated into **coastal erosion countermeasures** and **securing of water resources**. According to the undersecretary in the President's Office, all plans are linked to coastal erosion countermeasures and securing of water resources, and the most critical conditions exist in South Tarawa, where approximately 40,000 of the total population of 92,000[1] are living. The population of South Tarawa has almost doubled over the past 20 years, and population concentration here is far higher than on other islands. As a result, the coastline has been artificially modified, human impacts have been exerted on the actions of sand accumulation and erosion, which form atoll islands, and groundwater reserves are insufficient to satisfy the growing population. Accordingly, water supply needs to be rationed[2] in order to prevent excessive pumping.

Also, disaster prevention and coastal erosion countermeasures can be divided into structural measures and non-structural measures. Structural measures include the construction of seawalls and causeways, while non-structural measures include the establishment of disaster management measures, preparation of hazard maps, installation of early warning systems and establishment of evacuation setups, etc.

The following paragraphs describe specific countermeasures under each direction of support in Kiribati, while Table 3-4.2 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Development of Alternative Water Sources and Intensive Water Resources Management

i. Improvement of water supply in South Tarawa through groundwater development in North Tarawa and construction of facilities

The most effective way to counter the critical water shortages on South Tarawa is to develop new sources of water. Rainwater tanks have been installed, however, they have not led to fundamental improvements, and if the impacts of climate change become more pronounced in the current critical situation, even greater hardships can be expected. For this reason, a survey implemented by SOPAC indicates that there are three potential sites for new water sources in North Tarawa and that there are sufficient reserves of water to satisfy the demand in South Tarawa. Moreover, it is necessary to build water supply facilities in line with the development of new water sources, and Japanese prospecting technology can be fully utilized for effectively developing the freshwater lens and gauging the pumping potential.

Moreover, according to the Government of Kiribati, no other donors have declared willingness to give support in this area.

ii. Conservation of water lens through promoting rainwater recharging via community facilities

Promoting the recharging of rainwater to the ground is an effective means of preserving the freshwater lens. Every community in Kiribati has a meeting place referred to as a "*maniava*." These *maniava* have large roofs that can be used to efficiently collect rainwater, and this water can be recharged into the ground in order to preserve the freshwater lens and mitigate water shortages during the dry season. This measure is an example of an adaptation measure suited to the local conditions.

iii. Improvement of water supply on remote islands

Water shortages during the dry season are acute on remote islands. On these islands, since it is difficult to drill large-scale wells that require well drilling equipment, it is necessary to improve water supply conditions through installing basic facilities such as rainwater tanks and hand-dug wells. These are examples of adaptation measures that give consideration to human security.

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[1] National Statistics Office, Ministry of Finance, 2005 Census of Population, 2005

[2] Public water hydrants in South Tarawa supply water from 09:00 to 13:00. The daily water supply flow is 1,900 kℓ/day.

iv. Sanitary management and enlightenment activities in water management targeting communities

The rainwater tanks managed by communities and ordinary households are used to obtain potable water, however, sanitary conditions inside the tanks are poor. It is necessary to conduct enlightenment activities concerning the need for sanitary management and simple water treatment such as boiling water before drinking and to improve sanitary conditions inside households. Sustainable effects can be anticipated through collaborating with related agencies in this area.

v. Water resources management personnel training and capacity building

In Kiribati, there is an absolute shortage of technical capacity for compiling effective water resources development and conservation plans and water supply plans and for operating and maintaining such plans. Moreover, since excessive pumping is another cause of salinization, it is necessary to plan countermeasures based on legislation for restricting pumping and so on. Utilizing Japanese knowledge and experience, human resources can be trained to deal with such issues.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Establishment of the meteorological observation network

Kiribati has four meteorological observation stations: the station on Tarawa observes rainfall, temperature, wind direction, wind velocity, air pressure, humidity and evaporation, while the other stations observe rainfall and temperature[1]. However, observation data from remote islands are communicated by wireless telephones or satellite telephone, and regular interruptions to the transmission of meteorological data can prevent the safe and efficient implementation of response measures during disasters. In future, since it will be necessary to analyze meteorological data over units of 100 years in order to implement climate change countermeasures, it will be important to establish the meteorological observation network.

Japan has well developed meteorological observation networks which are used for predicting the occurrence of disasters and mitigation of damage. Accordingly, this is another area where Japanese experience and know-how can be amply utilized.

ii. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

Kiribati Meteorological Service has 24 employees. Concerning meteorological forecasts, it obtains data from Fiji and gives local forecasts over the radio. Out of the 24 employees, there are only three forecasters so it is urgently necessary to train more. Moreover, concerning disaster warnings, there are no criteria for issue and decisions are left up to each person in charge. In future, it is expected that rainfall patterns will change under the impacts of climate change, so forecasters will need to have even greater skill than at present. In addition, localized forecasting is not currently implemented, however, this will also become necessary for managing climate change risks in future.

Japan, which also has numerous natural disaster risks, has abundant experience, knowledge and know-how in this area and can thus make a major contribution to improving technology in Kiribati.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Compilation of infrastructure design criteria for disaster countermeasures

Since climate change causes external forces such as rainfall and high tides, etc. to change, it is necessary to consider such conditions when designing public facilities (infrastructure). Moreover, against the background of economic development, it is necessary to rebuild the existing public facilities. This is true not only of seawalls and other disaster prevention facilities but also ports, roads and bridges. Accordingly, through setting external force criteria

[1] See Annex 2-(2) Records of Discussions and Meetings.

that take climate change according to the service life and importance of facilities into account and establishing criteria for facility structures that can cope with climate change, it will be easier to address climate changes in future.

Since Japan has renewed its public facilities in line with its economic development, it can utilize its experience and history of guideline developments in Kiribati. Concerning maintenance too, examination of asset management is currently being advanced in Japan, and this technology can also be applied. As for design guidelines, some are included in the NAPA, however these are limited and it is necessary to include ideas for adapting to change. Since other donors hardly possess such experience at all, Japan can offer significant cooperation in this field.

ii. Coastal erosion countermeasures at Tungaru Hospital, causeway and surrounding areas on Tarawa

Examples of structural coastal erosion countermeasures in Tarawa are the area around Tungaru Central Hospital (constructed under Japan's grant aid[1]), the area around Bikenibeu Primary School, the causeway between Nanikai and Bairiki and so on. These coastal erosion countermeasures are currently being planned under KAPII, the local needs are high and survey has already been implemented by SOPAC[2]. In the case of Tungaru Central Hospital, countermeasures include moving some of the buildings back from the coastline.

SOPAC has surveyed the real situation and causes, etc. of coastal erosion, however, since SOPAC is basically an expert agency in the field of applied geosciences, whereas erosion countermeasures also entail engineering technology, it is thought that Japanese knowledge and experience can be greatly utilized in this field. In other words, it is appropriate to offer cooperation with countermeasures while making use of the analysis findings of SOPAC.

iii. Coastal erosion countermeasures at radio stations

As was described in vi. above, coastal erosion is advancing around the causeway between Nanikai and Bairiki, and there is a radio station situated halfway along this causeway. Part of the radial earth of the antenna for this radio station has already been washed away by coastal erosion. Kiribati comprises atoll islands scattered over a huge expanse of ocean and information communications between the capital and outlying provinces are vital, however, means of communication with outlying islands are scarce. The Broadcasting and Publishing Service has requested the government to conduct coastal erosion countermeasures to ensure the stable continuation of MW radio broadcasts. In the broadcasting field, there is large potential to make use of Japan's knowledge and experience; moreover, since Japan has implemented or is examining similar cooperation in Tuvalu and the Solomon Islands, good results can be anticipated from utilizing the outputs of this.

iv. Information collection on disaster countermeasures and coastal erosion

In order to elucidate the impacts of climate change and coastal erosion and examine countermeasures, it is necessary to accumulate data over the long term, and SOPAC, Australia and the United States are currently active in this area. These efforts are mainly directed to elucidating current conditions, however, there are still not enough data concerning climate change adaptation measures. Accordingly, it is necessary to accumulate data concerning the effects and impacts of adaptation measures. In particular, the effectiveness of disaster countermeasure facilities frequently only becomes clear after disasters occur, however, since disasters are rare occurrences, it takes a long time to build up data. Moreover, concerning coastal erosion, since topographical changes caused by fluctuations in meteorological conditions also need to be taken into account, it is necessary to clarify long-term mean changes and fluctuations. Accordingly, it is necessary to conduct disaster fact-finding surveys when cyclones and other disasters occur and collect information through the application of remote sensing.

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[1] Tungaru General Hospital Examination Room Expansion Plan (2001, grassroots grant aid)

[2] SOPAC, Technical Report – An assessment of coastal processes, impacts, erosion mitigation options and beach mining, December 2005

v. Capacity building of the National Disaster Committee

Concerning disaster management via non-structural methods, first the capacity building of the National Disaster Committee directly under the President's Office can be considered. In Kiribati, the KAP is being implemented and the NAPA has been compiled, however, the two plans lack consistency. Whereas the KAP is implemented by the President's Office, the NAPA is managed by the Ministry of Environment, Land and Agricultural Development, and it is necessary to provide the organizational capability to fully utilize the two adaptation programs. Through doing so, consistency can be secured between the two programs, thereby enabling efficient implementation. Japanese experience in this field can be utilized to support this organizational capacity building.

vi. Establishment of the disaster/disaster prevention radio network

The only means of communications between islands are wireless telephones or satellite telephones. However, it is hard to achieve stable communications especially in the case of wireless telephones, and this can become a major hindrance to securing safe and smooth responses in the event of disasters. Establishing a disaster communications network is an important element in climate change risk management. Japan has a proven track record in this technology.

vii. Integrated hazard map preparation and coastal management capacity building

In Kiribati, since various natural disasters such as hurricanes, high tides and tsunami, etc. are forecast, an effective countermeasure is to prepare an integrated hazard map. Since the country comprises atoll islands, land is restricted and it is difficult to secure evacuation sites. In these circumstances, preparing a hazard map and highlighting the vulnerability of residents to natural disasters in advance will prove effective for smoothly dealing with disasters.

Also, as is partially raised in KAPII, coastal management is required as a non-structural countermeasure. This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management. Accordingly, it is necessary to coordinate with other agencies and departments regarding this item.

In Japan too, the Coastal Law was revised to include disaster prevention, utilization and environmental objectives in 1999, while the Basic Ocean Law was enacted in 2007 in order to stipulate basic items regarding ocean development, utilization and environmental preservation. Japan can offer support based on these experiences.

viii. Disaster broadcasting capacity building

It is necessary to establish the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to providing prompt and reliable disaster information in Kiribati, where means of communication are fragile. This entails building the disaster broadcasting capacity through establishing the necessary organizational setup, etc. Even greater effects can be expected from this measure through implementing it in tandem with the countermeasures described in x.

ix. Installation of early warning systems

Establishing early warning systems is an effective measure for ensuring the safe and prompt evacuation of residents and mitigating damage at times of disaster in Kiribati, which is scattered over a wide area. Japan possesses a proven track record concerning this technology.

x. Dissemination and enlightenment activities

Raising the knowledge of residents concerning the various impacts of climate change promotes changed awareness among citizens and has the potential to bring forth autonomous climate change countermeasures on the community level. In Kiribati, where community ties are strong, climate change risk management can become a means of self defense and helps lowers risk at times of disaster occurrence.

xi. Technical improvement of coastal erosion countermeasures on remote islands

When implementing coastal erosion countermeasures on remote islands, in consideration of economic factors and maintenance, it is necessary to make use of local materials and

technologies. Concerning this, it is possible to transfer applicable technologies based on Japan's past and current experience and conditions on the ground in Kiribati. Moreover, the outcomes of these measures can be applied to similar remote islands and used to combat erosion.

Table 3-4.2 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Kiribati

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Development of alternative water source and integrated water resources management	Mitigate water shortages through securing new water sources for and ensuring the appropriate use of water in response to salinization arising from climate change and deficient water supply.	Short term	Improvement of water supply in South Tarawa through groundwater development in North Tarawa and construction of facilities	Develop the three potential sites for new water sources in North Tarawa that have already been assessed by the government, and construct water supply facilities, in order to fundamentally improve the water supply situation in South Tarawa.	A	
			Short term	Conservation of freash water lens through promoting rainwater recharging via community facilities	In order to efficiently collect rainwater, use the roofs of community facilities (maniava assembly halls) and percolate rainwater into the ground in order to restrict the salinization of the freshwater lens and thereby conserve the lens. This can be especially effective on remote islands that have no public water supply facilities	B	
			Medium to long term	Improvement of water supply on remote islands	Install rainwater tanks, etc. in order to improve water supply conditions in village communities.	B	
			Medium to long term	Sanitary management and enlightenment activities in water management targeting communities	Conduct sanitary management and water conservation in the rainwater tanks managed by communities and ordinary households. Also, cultivate know-how of sanitary management and conduct enlightenment activities in order to develop capacity for dealing with water shortages.	C	
			Medium to long term	Water resources management personnel training and capacity building	Implement training for government personnel in charge of water resources management and the staff of equipment management organizations. Also, prepare controls, etc. concerning excessive pumping to promote the appropriate use of existing water resources	C	
2.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Establishment of the meteorological observation network	Improvement and expansion of observation stations and observation points and establishment of data transmission equipment (including establishment of three new observation stations)	A	
			Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	B	○

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling criteria that take climate change into account, implement infrastructure development and design appropriately and efficiently. Select a number of conditions and compile criteria that can be applied to countries and regions with similar conditions.	A	○
			Short term	Coastal erosion countermeasures at Tungaru Hospital, the causeway and surrounding areas on Tarawa	Implement coastal erosion countermeasures through installing facilities for controlling waves and littoral drift making use of natural characteristics in the area around Tungaru Central Hospital (Bikenibeu district). The results of countermeasures in this project may also be examined for application to other countries.	A	
			Short term	Coastal erosion countermeasures at radio stations	Implement countermeasures (installation of wave dissipating or wave breaking walls, etc.) to prevent coastal erosion advancing around the radio station, and renew part of the antenna that has been washed away by coastal erosion.	A	
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	A	○
			Short term	Capacity building of the National Disaster Committee	Establish a disaster countermeasures code of conduct, compile evacuation plans and establish a disaster recovery fund (dispatch of advisors).	B	
			Short term	Establishment of the disaster/disaster prevention radio network	Secure stable communications between the National Disaster Committee in the President's Office and the provincial disaster committees.	B	
			Short term	Integrated hazard map preparation and coastal management capacity building	In addition to compiling an integrated hazard map that superimposes various types, improve management capacity with consideration given to land use and development controls, environmental conservation and utilization.	B	○
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to conducting the necessary broadcasting of disasters.	B	○
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the safe and prompt evacuation of residents and mitigate damage at times of disaster (linkage with meteorological observation stations is needed).	C	
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence (community disaster prevention).	C	○
			Medium to long term	Technical improvement of coastal erosion countermeasures on remote islands	Transfer technologies that are applicable to remote islands, based on consideration of economy, utilization of local materials and Japanese disaster countermeasures. Examine measures that can be applied to other remote islands (especially atoll islands) over a wide area.	C	

3-4-3 Papua New Guinea (PNG)

(1) Features of Support in Papua New Guinea

Climate change countermeasures in PNG need to cover a wide range. Within that, **disaster countermeasures** are viewed as a top priority in terms of both human security and coexistence with nature. Moreover, through taking advance disaster countermeasures (mitigation measures), it is possible to reduce the economic burden of disasters and ensure sustainable development.

Meanwhile, being a nation of islands, PNG has numerous coasts, and there are numerous reports of salinization advancing in such areas. Moreover, although annual rainfall is sufficient to supply the living water requirement, in highland areas and so on, drought damage is occurring and causing major economic losses during dry spells. Accordingly, **the securing of water resources is also an important issue**.

The following paragraphs describe specific countermeasures under each direction of support in PNG, while Table 3-4.3 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Development of Alternative Water Sources and Integrated Water Resources Management

i. Salinization countermeasures capacity building and master plan preparation

The central government is aware of the advance of well water salinization and recognizes the need for countermeasures. No survey has so far been implemented on the current condition of salinization. Accordingly, no technical data (distribution of the salinized area, degree of salinization) for compiling countermeasure have been accumulated. Moreover, salinization is a phenomenon occurring widely over coastal areas of PNG and cannot be resolved through building only a few facilities. Rather, it is necessary to compile a master plan of wide area with hard and soft measures from the short, medium and long term perspectives.

ii. Community development of ponds

Numerous communities exist in the mountain areas and these conduct water supply from various sources such as river water, groundwater, spring water and rainwater. However, due to the small scale of water supply facilities, water shortages are a frequent occurrence. Meanwhile, since there is abundant river water in the mountain areas, an effective measure is to construct basic facilities such as ponds to store river water and use it for various purposes. At the same time, village residents should be educated about the need for and methods of pond sanitary management.

iii. Water storage projects linked to micro hydropower

The mountain areas of PNG have high rainfall and abundant river water. In the capital Port Moresby, dam reservoir water is used for both public water supply and hydropower generation. Through developing water sources with the aim of utilizing abundant river water and improving water supply to the capital, provincial cities and district cities and communities, and combining these facilities with micro hydropower facilities, a major contribution can be made towards improving the power situation in Port Moresby and so on.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Construction of the meteorological observation network

PNG has 14 meteorological observation stations throughout the country and is planning to increase these to 23; however, there are no stations in highland areas and thus no awareness of weather conditions in the inner part of the main island. Moreover, since data from the meteorological observation stations are sent by telephone, facsimile or e-mail, data sometimes are lost due to the communication conditions. In future, as climate change is expected to cause more fluctuations in rainfall patterns, even greater reliability will be required from observation data. For this reason, it will be necessary to build the meteorological observation network so that observation data can be definitely collected in each area.

Japan has well developed meteorological observation networks which are used for predicting the occurrence of disasters and mitigation of damage. Accordingly, this is an area of support where Japanese experience and know-how can be amply utilized.

ii. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

The Meteorological Service has 66 employees, however, only six members (chiefs in each section) have WMO qualifications as forecasters. The Service previously conducted autonomous training of forecasters, however, this has been discontinued due to budget cuts, and training is now a matter requiring urgent attention. It is likely that climate change will bring about changes to conventional rainfall patterns from now on, and it will be necessary to conduct forecasting under various meteorological conditions over the diverse coastal and inland areas of PNG. Accordingly, forecasters will need to possess high level skills. In addition to changing rain patterns, since localized forecasting is also important for forecasting disasters, PNG is facing an urgent need to implement localized forecasting and disaster forecasting in order to manage climate change risks in future. Moreover, since AusAID already conducts meteorological data collection and support for WMO training, etc, activities will need to be coordinated with this support.

Since Japan possesses abundant experience, knowledge and know-how as a country that faces numerous natural disaster risks, it can make a major contribution to the enhancement of technology in PNG.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Compilation of infrastructure design criteria for disaster countermeasures

As is also the case in Kiribati, it is necessary to build public facilities (infrastructure) that can respond to external forces caused by climate change such as rainfall and high tides, etc. With respect to disaster prevention facilities such as seawalls, river embankments and erosion control facilities and public facilities such as roads and bridges, it is necessary to set external force criteria that take climate change according to the service life and importance of facilities into account, and establish criteria for facility structures that can cope with climate change. Doing this will make it easier to address climate changes in future. Moreover, since other donors hardly possess any experience in this field, Japan can offer support by making use of its unique experience and technology.

ii. Organizational strengthening of the National Disaster Center (functional strengthening and expansion)

PNG is faced with numerous disaster risks and the role of the National Disaster Center is extremely important. Accordingly, the National Disaster Center operates on a 24 hour basis. However, it only possesses 10 employees and poor communications with provincial disaster centers (using wireless, etc.) make operating conditions very difficult. Accordingly, in order to strengthen the organization of the National Disaster Center, it is necessary to strengthen and expand functions of the information network to facilitate prompt and stable implementation of countermeasures at times of disasters. Japan, as another country prone to natural disasters, has established information communication methods and facilities and can offer a lot of knowledge and experience in this field.

iii. Organizational strengthening of the Climate Change and Environmental Maintenance Department

As is mentioned in Chapter 2 and the section on early warning system installation, the National Broadcasting Authority is a member of the disaster committee in each province, and it implements disaster broadcasts according to requests from these committees. Communications in PNG are inadequate in remote islands and rural areas and radio is used as the most effective means of providing prompt information, etc. However, although national disaster information is provided as shortwave broadcasts transmitted from Port Moresby and relayed through local FM stations, relays cannot be extended to all 19 provinces. Moreover,

the branch stations in each province do not have equipment for making emergency broadcasts, and even the main station in Port Moresby can only make broadcasts when personnel are at work (broadcasting equipment is not equipped with emergency broadcast functions), thereby making it difficult to conduct emergency broadcasts at nighttime. Taking the communications situation in PNG into consideration, there is no doubt that radio broadcasting plays an important role in mitigating disasters, and there is urgent need to install functions for making emergency disaster broadcasts in order to mitigate disasters. Furthermore, this countermeasure is implemented or planned in Tuvalu and other Pacific island nations, and major outputs can be anticipated from Japanese support in this field.

iv. Integrated hazard map preparation

Since PNG faces various disaster risks, it is important to prepare a hazard map that enables various hazards (disaster risks) to be comprehensively gauged. Moreover, since geographical conditions differ greatly in each area, understanding what kinds of disaster risk exist is essential for taking disaster countermeasures. In Japan, numerous integrated hazard maps have been compiled mostly by local governments, and this experience and know-how can be fully utilized in PNG too.

As was stated in the section on Kiribati, coastal management is also required as a non-structural measure. This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management, and support can be provided based on Japan's experience.

v. Installation of early warning systems,

For PNG, which comprises scattered islands of various sizes and is confronted with numerous kinds of disaster risk, the installation of early warning systems is an effective means of ensuring the safe and fast evacuation of residents and mitigating damage when disasters occur. The Meteorological Service of PNG conducts observations at various locations, however, forecasters who possess forecasting ability are only assigned in Port Moresby. As a result, emergency communications based on information from the Meteorological Service at times of disaster are transmitted from the National Disaster Center to provincial and local disaster committees, and then onto residents. Information is provided to residents via radio broadcasts, however, information on evacuation, etc. is provided to the radio stations from the provincial disaster committees. In cases of disasters, when there is no time to spare, it is necessary to have radio broadcasts as a means of rapidly transmitting warnings. It is necessary to install early warning systems in affected areas in order to assess the level of urgency of the disaster risk and the speed of evacuation. Moreover, since Japan has a proven track record concerning this technology, it can fully utilize this in providing support.

vi. Disaster broadcasting capacity building

Although emergency broadcasts are already implemented at times of disaster in PNG, the role of broadcasting, a code of conduct and guidelines for use at times of disaster have still not been established. In order for emergency broadcasts to provide disaster information with even greater speed and reliability in this country where the information communications network is so fragile, it will be necessary to establish these items. Through building the organizational setup required for emergency disaster broadcasting and raising the capacity of broadcasting, this will contribute to mitigating disaster damage amidst projections of increased vulnerability in the future. An even higher effect can be realized from these measures through combining them with the measures described in viii.

vii. Information collection on disaster countermeasures and coastal erosion

In PNG, the area causing the greatest concern is the frequent occurrence of natural disasters affected by climate change. In particular, extreme meteorological phenomena will trigger flooding and sediment disasters mainly around rivers, while cyclones will incur high tides and major damage along coasts. In inland areas, steps need to be taken against drought and frost damage, so countermeasures against natural disasters will differ greatly depending on the area and local geographical conditions. However, the central government doesn't have the capacity

to collect and manage various information from each area, so there is a high need to prepare a master plan of measures. Methods for collecting information concerning disasters and disaster countermeasures from the long-term viewpoint will be examined and implemented in order to enable responses to disasters arising out of climate change.

viii. Bridge and national highway disaster prevention measures

Concerning disaster prevention works on trunk roads and bridges in PNG, since bridges over rivers are especially vulnerable, there are high needs for cooperation in this area. Japan has supported bridge construction in highland areas under the grant aid scheme. Through continuing these works, it will be possible to secure physical distribution, mitigate economic losses and ensure the security of people living in the areas concerned. Also, doing this will mitigate vulnerability to disasters arising from climate change.

ix. Dissemination and enlightenment activities

As was described in the sections on Nauru and Kiribati, raising the knowledge of residents concerning the various impacts of climate change promotes changed awareness among citizens and has the potential to bring forth autonomous climate change countermeasures on the community level. PNG has the largest population (5.9 Million) in the Pacific region, so it will take a long time for individual measures to spread to all parts of the country. Accordingly, encouraging communities to autonomously take risk management measures with respect to climate change based on dissemination and enlightenment activities will contribute to the effective mitigation of risks at times of disaster.

Table 3-4.3 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Papua New Guinea

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Development of alternative water source and integrated water resources management	Comprehensively manage water from sources to public supply in order to mitigate and adapt to the impacts of climate change in the water resources field.	Short term	Salinization countermeasures capacity building and master plan preparation	In order to gauge the conditions of salinization and link them to future countermeasures, carry out the data collection concerning affected areas and the necessary salinization countermeasures.	A	
			Short term	Community development of ponds	Utilizing river water in mountain areas, build ponds in each community in order to secure stable water resources. Also, cultivate sanitary management capability in the communities and conduct dissemination and enlightenment activities for residents in order to ensure stable water resources.	B	
			Medium to long term	Water storage projects linked to micro hydropower	Conduct projects linked to micro hydropower development in order to secure water sources and improve the electricity situation in urban areas.	C	
2.	Meteorological observation capacity building relating to climate change上	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Establishment of the meteorological observation network	Improvement and expansion of observation stations and observation points and establishment of data transmission equipment	A	
			Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	B	○

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling design criteria on infrastructure development that take climate change into account, implement approproate and efficient design and development of infrastructure. When doing this, first fully consider the environmental impacts by analysing sediment balance, etc. Select common conditions and compile criteria that can be applied to countries and regions with similar conditions.	A	△ (Since the scale of rivers and sediment buildup are extremely large and conditions for securing aggregate, etc. also differ).
			Short term	Organizational strengthening (functional strengthening and expansion) of the National Disaster Center	Establishment of a disaster countermeasures plan and functional expansion of the disaster communication network	A	
			Short term	Organizational strengthening of the Office of Climate Change and Environmental Sustainability (improvement of coordination capacity)	Dispatch of planning surveyors	A	
			Medium to long term	Installation of equipment for application to disaster broadcasting	Many natural disasters in PNG require emergency evacuation, and equipment installation is needed in order to implement smooth and stable emergency broadcasts at times of disaster. The national broadcasting network will be improved and expanded, while emergency broadcasting functions (countermeasures and functions following the end of regular broadcasts) will be added, etc.	A	
			Short term	Integrated hazard map preparation	Compile integrated hazard maps that superimpose various types of hazards.	B	○
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the safe and prompt evacuation of residents	B	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to conducting the necessary broadcasting of disasters.	B	○
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	B	○
			Medium to long term	Bridge and national highway disaster prevention measures	Implement disaster prevention works for bridges and trunk roads, etc. that are vulnerable to disasters caused by climate change (securing of bridge clearance from river beds, etc.)	B	
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence.	C	

3-4-4 Vanuatu

(1) Features of Support in Vanuatu

Vanuatu, which is situated in the path taken by cyclone and possesses isolated geographical conditions, has seven active volcanoes and is always at risk from volcanic eruption. It is one of the most vulnerable countries to natural disasters in the South Pacific. The impacts of climate change magnify this vulnerability of Vanuatu to natural disasters. Accordingly, as a means of realizing human security concerning climate change, **natural disaster countermeasures** should be made the priority area of support in Vanuatu. Concerning the targets of measures, coastal erosion and high tides are the most acute phenomena, and these are followed by flooding and sediment damage. Moreover, when the scale of natural disasters is compared to the scale of the Vanuatu economy, there is a limit to hard measures such as facilities construction, so emphasis has to be placed on soft measures. It is essential to strengthen the functions of the National Disaster Management Office which executes these.

Moreover, as was demonstrated by the case at the end of March 2009, when eruption of Mt. Ambrym severed the water supply for approximately 5,000 villagers and led to the issue of an emergency request for assistance, an important measure in the volcanic nation of Vanuatu is to establish a **potable water emergency transport system** at times of natural disasters.

The following paragraphs describe specific countermeasures under each direction of support in Vanuatu, while Table 3-4.4 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Development of Alternative Water Sources and Integrated Water Resources Management

i. Nationwide emergency water shortage countermeasures

Recently water shortage took place due to rainfall contamination by volcanic eruption in Ambrym Island. It is pointed out that water shortage will take place again due to the same reason around Ambrym Island and surrounding remote small islands. Accordingly, it is necessary to construct emergency water purification facilities and additional distribution reservoirs, install portable membrane purification facilities and provide water trucks, etc. in the capital Port Vila. In particular, Japanese experience and know-how can be utilized in proposing portable membrane water purification facilities. In carrying out support, it is necessary to make sure that no competition arises with Union Electric Du Vanuatu Ltd (UNELCO), in charge of water supply in the capital.

ii. Nationwide water supply and demand improvement

Vanuatu is composed of numerous islands, and many areas have fragile water supply facilities and are vulnerable to water shortages during dry spells and droughts. For example in Luganville, new groundwater development for stable water supply is requested, because the existing spring at hill-side, which is source for the current water supply, is susceptible to damage by drought. Close relationship between drought and El- Niño phenomena is emphasized in Vanuatu. Seriousness of drought is dominated by relative relation between rainfall and water consumption. It means that even though rainfall condition is same, damage by drought is different between urban area and rural area. According to the past examples in Vanuatu, there is high possibility of drought disaster throughout the country, when annual rainfall falls down to a half of the average annual rainfall.

Following situation mentioned above, giving priority to areas where water shortages have been reported or are feared, it is necessary to collect hydrological data on rainfall and river flow, etc. in order to gauge the potential for water resources development, to survey the utilization of potable water and other living water and survey the supply and demand situation through collating both sets of data. Water supply and demand survey is an essential item in planning water supply facilities, and the findings from such surveys make it possible to plan the optimum supply facilities. Since Japan has a lot of experience and technology in water supply and demand surveying and analysis of water resources development potential especially, it can provide effective support in this area.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

In order to support the organization and analysis of collected data for meteorological forecasting from now on, a JICA senior volunteer has been dispatched to the Meteorological Service since 2008. Amidst staff shortages and an inadequate work setup, it will be necessary to establish an ongoing training system in order to realize efficient data analysis, enhance meteorological forecasting technology and improve the capacity to analyze meteorological data related to climate change. It is desirable to utilize and collaborate with the outputs of the meteorological warning and forecasting capacity building and network establishment project that has already been started in Fiji.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Organizational strengthening of the National Disaster Management Office

Since the National Disaster Management Office mainly concentrates on volcanic disaster countermeasures due to staff shortages, it lacks experience and has not prepared countermeasure action guidelines or rescue training manuals concerning cyclones and flooding. Accordingly, it is necessary to compile disaster crisis management plans, establish countermeasure manuals, implement rescue training and guidance, and establish equipment for public information activities, and disseminate these resources to local public authorities.

ii. Installation of early warning systems

Vanuatu is elongated from north to south, and it currently has clear vulnerability in making warning communications and evacuation notifications due to breakdown of the communications network. In these circumstances, communities are required to issue early warnings and evacuate themselves. Accordingly, there is an urgent need to establish early warning facilities. Concerning the setting of warning criteria and establishment of evacuation action manuals in communities, it is necessary for the Meteorological Service and National Disaster Management Office to work together. Japanese has a proven track record in this area.

iii. Disaster broadcasting capacity building

Many citizens in Vanuatu obtain information on disasters from the radio. Accordingly, appropriate instructions are required concerning precautions, advance preparations and evacuation. Since broadcasting greatly contributes to reducing damage at times of disasters, it is necessary to clarify a code of conduct and guidelines and support the improvement of the broadcasting capacity of media in order to provide fast and reliable disaster information.

iv. Urban drainage countermeasures

The tourism industry accounts for 40% of GDP in Vanuatu and is largely based in the capital Port Vila and regional city of Luganville. Since inundation of city roads and commercial facilities at times of torrential rain adversely affects tourism, it is necessary to improve drainage in order to keep the living environment in sound condition. Introducing planning, design and execution technology from Japan can be effective in this area.

v. Coastal erosion countermeasures

Airports and tourist spots have been developed on remote islands, and roads are an important infrastructure for moving tourists around. Now coastal erosion is advancing and road maintenance has become an urgent issue. Moreover, since coastal erosion is also advancing along roads linking provincial cities and communities, seawall measures are needed. Utilizing Japanese experience and introducing planning, design and execution technology from Japan can be effective in the area of coastal conservation.

vi. Compilation of infrastructure design criteria for disaster countermeasures

The existing disaster prevention facilities were constructed according to planning criteria and designs based on past natural conditions. Through compiling infrastructure development and design criteria that take future climate change into account, infrastructure that is resistant to disaster risks can be designed and developed appropriately and efficiently. Concerning coastal

facilities and river structures, etc., it is necessary to select the external conditions for planning and design and compile criteria that can be applied to other countries and areas with similar conditions.

vii. Integrated hazard map preparation and coastal management capacity building

Basic volcano hazard maps have been prepared under French support for four islands including Ambae. Meanwhile, the National Disaster Management Office is examining disaster mitigation activities through compiling cyclone, flood and tsunami hazard maps and giving advance notice to residents. Since evacuation centers, evacuation routes, risk areas, relief facilities and public facilities (police stations, hospitals, schools, churches) are common items on all hazard maps, the preparation and dissemination of integrated hazard maps that superimpose multiple risk maps (cyclones, flooding, tsunami) is essential for community disaster prevention activities. Since Japan has developed high hazard map compilation ability while overcoming various natural disasters, it is well qualified to provide support in this area.

Moreover, as is also the case in Kiribati, coastal management is required as a non-structural countermeasure. This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management. Accordingly, it is necessary to coordinate with other agencies and departments regarding this item, and Japan can provide support based on its experience with development and utilization of coastal areas and conservation of marine environment.

viii. Dissemination and enlightenment activities

It is necessary to inform residents about the human damage and property losses resulting from widespread inundation caused by rising sea level, cyclones, high wind pressure and torrential rains in the past. Raising the knowledge of residents concerning the various impacts of climate change mitigates the level of risk at times of disaster. Countermeasures that utilize traditional community ties are readily acceptable to citizens and are effective.

ix. Coastal national highway and bridge disaster prevention measures

Construction of roads for moving tourists around greatly contributes to the economic effect of the tourism industry. Even now, coastal roads and bridges without seawalls are damaged and in need of repairs. Accordingly, the implementation of countermeasure works on coastal trunk roads and bridges, which are vulnerable to risks from climate change disasters, is necessary for promoting tourism and maintaining the living environment of coastal residents. Japanese road and bridge construction technology has already been successfully conducted in the Solomon Islands and so on and can be utilized in Vanuatu too.

x. Information collection on disaster countermeasures and coastal erosion

When compiling countermeasures against coastal erosion, it is necessary to observe long-term changes of coastal areas and accumulate data. However, Vanuatu does not possess sufficient human resources, experience or equipment to implement coastal monitoring on so many islands. Furthermore, in order to identify the areas that are prone to natural disasters and effectively enlighten citizens about disaster countermeasures and evacuation activities, satellite image analysis following the occurrence of cyclones, flooding, earthquakes and tsunami is effective. Japanese technology in this field can be utilized in support.

xi. River flooding countermeasures

More and more people concerned with the tourism industry are living in the district of Mere near the capital Port Vila. Although community flood prevention activities have been implemented under support from SOPAC, flooding and inundation are still occurring regularly, and it is necessary to carry out structural measures (river course improvement and outfall channel construction, etc.) for protecting residents' assets and maintaining the living environment. Japan's technical prowess in the field of river flooding countermeasures has been well received in a JICA development study conducted in Fiji, and it can also be applied to Vanuatu.

xii. Construction of regional city drainage facilities

Sarakata River on Espiritu Santo Island frequently overflows its banks due to torrential rain during the rainy season, and residents living alongside the river suffer repeated flood damage. Moreover, in Luganville, houses in low-lying areas become inundated and residents are forced to evacuate every time torrential rain falls. Also, inundation causes roads to become impassable and water inside public water supply facilities to become contaminated. Occurrence of flood damage in regional cities is thus greatly impeding citizen lifestyles. Japan possesses abundant experience concerning urban drainage countermeasures, and the said damage can be mitigated through applying design and execution technology based on this experience.

Table 3-4.4 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Vanuatu

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Development of alternative water source and integrated water resources management	Comprehensively manage water from sources to public supply in order to mitigate and adapt to the impacts of climate change in the water resources field.	Short term	Nationwide emergency water shortage countermeasures	In order to address acute water shortages all over the country, construct water purification facilities and additional distribution reservoirs and provide water trucks, etc. in the capital Apia.	A	
			Medium to long term	Improvement of nationwide water supply and demand	Particularly in areas where there are reports and fears of water shortages, gauge water sources and demand for potable water and other living water via social surveys. Also, survey rainfall and river flow with a view to gauging and improving the usable water flow.	B	
2.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	A	○

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Organizational strengthening of the National Disaster Management Office	Compile of a disaster crisis management plan, establish a disaster countermeasures action manual, implement and provide guidance on rescue training, and install equipment for public information activities.	A	
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the smooth and prompt evacuation of residents (linkage with meteorological observation stations is needed).	A	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to building media capacity for conducting the necessary broadcasting of disasters.	A	○
			Short term	Construction of urban drainage facilities	Construct drainage channels in the capital Port Vila in order to prevent the inundation of commercial facilities and protect the tourism industry.	A	
			Short term	Coastal erosion countermeasures	Implement coastal erosion countermeasures in order to protect trunk roads leading to airports on remote islands.	A	
			Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling criteria that take climate change into account, implement infrastructure development and design appropriately and efficiently. Select a number of conditions and compile criteria that can be applied to countries and regions with similar conditions.	B	○
			Short term	Integrated hazard map preparation	Compile integrated hazard maps that superimpose various types of hazards.	B	○
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence	B	○
			Short term	Coastal highway and bridge disaster prevention measures	Implement disaster prevention works for bridges and trunk roads, etc. that are vulnerable to disasters caused by climate change.	B	
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	C	○
			Medium to long term	River flooding countermeasures	Take steps to prevent the flooding of Mere River in the capital Port Vila, where rapid population growth is happening.	C	
			Medium to long term	Construction of regional city drainage facilities	Implement flood countermeasures on Sarakata River on Santo Island and rainwater drainage measures in Luganville.	C	

3-4-5 Samoa

(1) Features of Support in Samoa

Samoa comprises two main volcanic islands surrounded by coral reefs, and these islands have precipitous terrain. Most of the population live in coastal areas and are directly confronted by the threat of natural disasters such as cyclones and high tides. They are also exposed to flooding and sediment disaster risks. In future, as the impacts of climate change became more manifest, the lives and property of residents will be further threatened. Accordingly, from the viewpoint of ensuring human security, the top priority support area in Samoa should be **natural disaster countermeasures**. Meanwhile, the World Bank has compiled a master plan of coastal area infrastructure management in Samoa and proposed various hard (structural) and soft measures When conducting Japanese support, making use of these outputs is desirable from the viewpoint of coordinating with other countries' aid agencies. At the same time, steps need to be taken to strengthen the National Disaster Management Office, which is in charge of natural disaster affairs.

Concerning water resources, in remote island areas of Samoa where surface water and groundwater resources are scarce and people rely on rainwater, extended dry spells and droughts can cause critical water shortages. Therefore, **emergency water shortage countermeasures** are the next most important support area behind natural disaster countermeasures.

Based on the above viewpoints, the following paragraphs describe specific countermeasures under each direction of support in Samoa, while Table 3-4.5 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Development of Alternative Water Sources and Integrated Water Resources Management

i. Nationwide emergency water shortage countermeasures

In order to address the acute water shortages arising in the capital Apia and all over Samoa, it is necessary to construct emergency water purification facilities and additional distribution reservoirs and provide water trucks, etc. It is important to implement cooperation in collaboration (financial and human resources development) with the EU, which is a major donor in the water supply sector. Japanese waterworks facilities and equipment, for example, portable membrane water purification facilities, comprise sophisticated technology and can be utilized in this area.

ii. Nationwide water supply and demand improvement

There are parts of Upolu Island and Savai'i Island that do not possess water supply facilities. Accordingly, it is necessary to collect hydrological data on rainfall and river flow, etc. in order to assess the potential for water resources development and water supply flow. At the same time, it is necessary to survey the utilization of potable water and other living water and finally estimate the supply and demand situation through collating both above sets of data. Water supply and demand survey is an essential item in planning water supply facilities, and the findings from such surveys make it possible to plan the optimum water supply facilities. It is important to implement cooperation in collaboration (financial and human resources development) with the EU, which is a major donor in the water supply sector in Samoa.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Expansion of meteorological observation facilities

As the preparatory stage for mitigation of cyclone and flood disasters, it is necessary to forecast the path of cyclones and whereabouts of localized rainfall. In particular, since floods in Samoa arrive quickly in 1~3 hours, existing observation facilities are unable to offer sufficient protection.

Accordingly, it is necessary to expand meteorological observation facilities (radar rain gauges and facilities for the real-time collection and transmission of observation data, etc.).

ii. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

Three JICA senior volunteers are currently dispatched to provide support for meteorological observation and forecasting technology. At the same time, JICA has supplied meteorological observation equipment (currently in operation). Since the local side has requested equipment installation support for forecasting the paths of cyclones and whereabouts of localized rain, it is necessary to establish an ongoing training system that entails implementation of training in equipment use and staging of drills in data building and analysis and meteorological forecasting, etc. It is desirable to coordinate with the meteorological warning and forecasting capacity building project that has already been started in Fiji.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Organizational strengthening of the National Disaster Management Office

The legal system for disaster prevention in Samoa is now being constructed under support from donors and international agencies, however, the National Disaster Management Office only has three employees. Since the NDMO has so far mainly concentrated on tsunami countermeasures and activities, it lacks action guidelines, rescue training manuals and experience concerning flooding. Meanwhile, communities and media agencies are aware of their need to collaborate with disaster prevention activities. Therefore, it is necessary for the central offices to jointly work on making advance preparations and conducting education on evacuation. For this reason, more effective disaster prevention activities can be realized through compiling a disaster crisis management plan, preparing disaster countermeasure action manuals, implementing and instructing rescue training, installing equipment for public information activities, and disseminating these resources to the media and communities.

ii. Installation of early warning systems

Since rivers in Samoa have step gradients and flood arrival times are fast, conventional warning communications are too slow to ensure timely evacuation. Accordingly, it is necessary for the communities to install sirens and other alarm systems linked to rain gauges and water level gauges and to conduct autonomous evacuation activities. Concerning the setting of warning criteria and preparation of evacuation action manuals that fit with each community, it is necessary to work with the Meteorological Service and National Disaster Management Office. Moreover, Japan has abundant experience of early warning systems and can provide effective support in this area.

iii. Urban river flooding countermeasures

Flash floods caused major damage along Vaisigano River in the capital Apia in 2001 and 2006. Apia has a high need for flood countermeasures in order to preserve the capital functions and ensure the sustainable development of the tourism industry. SOPAC has implemented support for flood risk management capacity building, during which it conducted flood analysis, model verification, evacuation planning and outline flood control planning.

iv. Disaster broadcasting capacity building

Citizens in Samoa obtain information on disasters from the TV and radio. Since broadcasting greatly contributes to reducing damage at times of disasters, it is necessary to clarify a code of conduct and guidelines, etc. for broadcasting stations and provide fast and reliable disaster broadcasts. Towards this end, it is necessary to support broadcasting capacity building of the media. This need is recognized and stipulated in the national disaster management implementation plan too.

v. Compilation of infrastructure design criteria for disaster countermeasures

Overtopping waves can be frequently seen occurring over the breakwater at Apia Port and the seawall of the coastal road. Since existing infrastructure facilities were constructed according to planning criteria and designs based on past natural conditions, they will be vulnerable to future disaster risks. Through conducting infrastructure design and development that take future climate change into account, infrastructure that is resistant to disaster risks can be designed and developed appropriately and efficiently. Concerning coastal facilities and river structures, etc., it is necessary to select the external conditions for planning and design and

compile criteria that can be applied to other countries and areas with similar conditions. Japan's abundant experience in this field can be put to good use here.

vi. Integrated hazard map preparation and coastal management capacity building

The National Disaster Management Office plans to conduct disaster mitigation activities through compiling cyclone, flood and tsunami hazard maps and notifying them to residents in advance. The World Bank has already compiled basic hazard maps for coastal areas via the Coastal Infrastructure Management (CIM) programme in 41 administrative districts of Samoa. Through collaborating with the World Bank to prepare and disseminate integrated hazard maps that superimpose multiple risk maps (cyclones, flooding, tsunami), it will be possible to facilitate more effective community disaster prevention activities.

Furthermore, as is also the case in Kiribati, coastal management is required as a non-structural countermeasure. This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management. Accordingly, it is necessary to coordinate with other agencies and departments regarding this item, and Japan can provide support based on its experience with development and utilization of coastal areas and conservation of marine environment.

vii. Dissemination and enlightenment activities

Due to the rising sea level and emergence of cyclones, inundation is occurring over increasingly wider areas. It is necessary to inform residents about the human damage and property losses resulting from inundation and sediment disasters caused by rising high wind pressure and torrential rains accompanying cyclones. Compared to structural countermeasures, dissemination and enlightenment activities are cheap, immediately effective and do not place a burden on the government. Moreover, self-defense measures that utilize community ties are effective.

viii. Coastal national highway and bridge disaster prevention measures

NAPA has already pointed out that infrastructure development is important for ensuring the sustainable growth of tourism, and the construction of roads for moving tourists around greatly contributes to the economic effect of the tourism industry. Even now, coastal roads and bridges without seawalls are damaged and in need of repairs. Accordingly, the implementation of countermeasure works on coastal trunk roads and bridges, which are vulnerable to risks from climate change disasters, is necessary for promoting tourism and maintaining the living environment of coastal residents. This proposal complies with the priority work of NAPA in Samoa, and also offers an opportunity to make use of excellent Japanese planning, design and execution technology in this area.

ix. Community infrastructure construction works

Infrastructure rehabilitation plans in each administrative district have been proposed under the coastal infrastructure management plan and risk management component proposed under support from the World Bank in 1999. It is anticipated that town development projects offering strong resistance to natural disasters will be implemented based on this plan. Implementing this work as a Japanese support undertaking based on the outputs of the World Bank may be a significant precedent for collaboration.

x. Information collection on disaster countermeasures and coastal erosion

When elucidating and compiling countermeasures against disasters and coastal erosion, it is necessary to collect data over the long term. In Samoa, the SPREP headquarters is involved with ecosystem conservation, environmental monitoring and the information resources center, and conditions are good for training human resources for information collection. Moreover, the Ministry of Environment and Natural Resources has a map server and GIS technology. It is necessary to collect information and conduct satellite image analysis following the occurrence of cyclones, flooding, earthquakes and tsunami, in order to monitor landslide sites and coastlines and utilize the data in the study, planning and design of sediment disaster and coastal erosion countermeasures.

xi. Disaster assessment capacity building

Samoa has a relatively high level of social infrastructure facilities. Infrastructure facilities including lifelines are viewed as important assets of the people. Calculating the costs of natural disaster damage and assessing recovery expenses facilitates rapid recovery and aids the sound protection of infrastructure. Japan has abundant experience regarding these techniques and can offer effective support in this area.

Table 3-4.5 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Samoa

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Development of alternative water source and integrated water resources management	Comprehensively manage water from sources to public supply in order to mitigate and adapt to the impacts of climate change in the water resources field.	Short term	Nationwide emergency water shortage countermeasures	In order to address acute water shortages all over the country, construct water purification facilities and additional distribution reservoirs and provide water trucks, etc. in the capital Apia.	A	
			Medium to long term	Improvement of nationwide water supply and demand	Conduct long-term monitoring of the volume and quality of surface water and groundwater to gauge the useable volume of water and ensure appropriate water intake.	B	
2.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Expansion of meteorological observation facilities	Install meteorological observation equipment necessary for the real-time observation, transmission and analysis of data for forecasting cyclone paths and localized rainfall.	A	
			Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	A	○

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Organizational strengthening of the National Disaster Management Office	Compile of a disaster crisis management plan, establish a disaster countermeasures action manual, implement and provide guidance on rescue training, and install equipment for public information activities.	A	
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the smooth and prompt evacuation of residents (linkage with the Meteorological Service and National Disaster Management Office is needed).	A	
			Short term	Urban river flooding countermeasures	Implement river improvement works to counter flooding on Vaisigano River running through the capital Apia.	A	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to building media capacity for conducting the necessary broadcasting of disasters.	A	○
			Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling criteria that take climate change into account, implement infrastructure development and design appropriately and efficiently. Select a number of conditions and compile criteria that can be applied to countries and regions with similar conditions.	B	○
			Short term	Integrated hazard map preparation	Compile integrated hazard maps that superimpose various types of hazards.	B	○
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence.	B	○
			Short term	Coastal highway and bridge disaster prevention measures	Implement disaster prevention works for bridges and trunk roads, etc. that are vulnerable to disasters caused by climate change.	B	
			Medium to long term	Community infrastructure construction works	Promote community building that is resistant to natural disasters based on the Coastal Infrastructure Management (CIM) programme.	B	
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	C	○
			Medium to long term	Disaster assessment capacity building	Improve capacity for assessing the extent of damage following disasters and cost of damage and restoration of public facilities.	C	

3-4-6 Tonga

(1) Features of Support in Tonga

Tonga is composed of volcanic islands and atoll islands and has many low-altitude remote coral islands, where people depend on rainwater for living purposes. Groundwater resources also exist, however, these cannot be used for drinking due to salinization. There is concern that climate change will further aggravate water shortages in the future. Accordingly, support for Tonga should be directed towards **water shortage countermeasures** from the viewpoint of securing human security.

Moreover, coastal areas, where most of the people live, are regularly hit by cyclones that threaten the safety of citizens. However, the meteorological observation setup and disaster countermeasure system with respect to cyclones are highly inadequate: for example, the Meteorological Service obtains cyclone information from its counterpart in Fiji and its observation instruments lack sufficient functions. Furthermore, the Meteorological Service and National Emergency Management Office, which are in charge of natural disaster countermeasures, have very weak organization and are unable to fulfill their duties. In these circumstances, support is required in the area of **natural disaster countermeasures**, and such support should comprise comprehensive measures including hard measures (structures), soft measures and functional strengthening of responsible agencies.

The following paragraphs describe specific countermeasures under each direction of support in Tonga, while Table 3-4.6 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Development of Alternative Water Sources and Integrated Water Resources Management

i. Nationwide emergency water shortage countermeasures

Tonga is composed of numerous islands that experience regular acute water shortages caused by natural disasters such as cyclones and volcanic eruptions. In order to address such acute water shortages, it is necessary to construct emergency water purification facilities and additional distribution reservoirs, install portable membrane purification facilities and provide water trucks, etc. in the capital Nuku'alofa. In particular, Japanese experience and know-how can be utilized in proposing portable membrane water purification facilities.

ii. Survey of groundwater reserves and monitoring of water quality

Many of the islands of Tonga are coral islands with high permeability. This means that the islands have abundant groundwater resources but scarce surface water for drinking and living purposes. Before formulating water supply plans, it is first important to assess available freshwater resources and development potential on each island. Groundwater resources are thought to be the main source of water supply in Tonga, however, it is necessary to survey long-term storage in the groundwater lens and gauge how much water is available for development on Tongatapu and other islands in order to ensure the appropriate intake volume. Japanese sophisticated groundwater prospecting and analysis technology can be used for surveying the volume of groundwater reserves.

iii. Water leakage countermeasures and water saving

Amidst concerns that freshwater resources in the capital Nuku'alofa will run short in the long term, it is necessary to promote efficient water use through preventing leakage and promoting water conservation. This entails gauging leakage flow and leak areas from water supply facilities and promoting the efficient utilization of resources through implementing leakage prevention measures. It is also necessary to educate citizens in water saving techniques. Since water leakage and saving countermeasures will target the capital and will not require expensive hard facilities, they can have a high introduction effect. Japanese water leak search instruments and technology are of a high level and can be utilized in this area of support. Moreover, conserving water through education is an effective measure for mitigating climate change.

iv. Nationwide water supply and demand improvement

Tonga is composed of numerous islands, and many areas have fragile water supply facilities and are vulnerable to water shortages at certain times. Targeting areas where water shortages

have been reported or are feared, it is necessary to collect hydrological data on rainfall and river flow, etc. in order to assess the potential for water resources development, to survey the utilization of potable water and other living water, and to survey the supply and demand situation through collating both above sets of data. Water supply and demand survey is an essential item in planning water supply facilities, and the findings from such surveys make it possible to plan the optimum supply facilities. Since Japan has a lot of experience and technology in water supply and demand surveying and analysis of water resources development potential especially, it can provide effective support in this area.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

The Meteorological Service relies on its counterpart in Fiji to obtain cyclone information; moreover, it is faced with staff shortages and harsh working conditions. In these circumstances, JICA senior volunteers were dispatched in March 2009 and are implementing training on data organizing and analysis and forecasting technology. Also, AusAID has commenced support involving the supply of meteorological observation equipment.

It is necessary to establish an ongoing training system in order to realize efficient data analysis and enhance meteorological forecasting technology. Since meteorological observation stations are scattered over the expansive national land that stretches over 1,000 km from north to south, it is desirable for experts to conduct traveling guidance. Also, it is desirable to utilize and collaborate with the outputs of the meteorological warning and forecasting capacity building project that has already been started in Fiji.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is explained below:

i. Organizational strengthening of the National Emergency Management Office

The National Emergency Management Office (NEMO), which belongs to the Ministry of Public Works, has six employees. It conducts emergency transmissions of disaster information via satellite telephone to Hawaii and Fiji. Since it has mainly been involved in countermeasures regarding tsunami disasters, it lacks experience and has not prepared countermeasure action guidelines or rescue training manuals concerning cyclones and flooding. The government is anticipating support activities from the Red Cross and NGOs. Accordingly, for the sake of realizing effective disaster prevention activities, it is necessary to compile disaster crisis management plans, establish countermeasure manuals, implement rescue training and guidance, and establish equipment for public information activities, and disseminate these resources to the Red Cross, NGOs and communities. Japan has ample experience and achievements in this field.

ii. Installation of early warning systems

Tongatapu Island has many lowland areas and needs early warning systems to warn against high tide disasters caused by cyclones. Accordingly, it is necessary for the communities to install sirens and other alarm systems linked to rain gauges and water level gauges and to conduct autonomous evacuation activities. It is urgently necessary to install early warning facilities for this purpose. Concerning the setting of warning criteria and preparation of evacuation action manuals, it is necessary to work with the Meteorological Service and National Emergency Management Office. Moreover, Japan has abundant experience of manufacturing and installing early warning systems and can provide effective support in this area.

iii. Disaster broadcasting capacity building

Cyclone information is transmitted from the Meteorological Service to the National Emergency Management Office (NEMO), and then from NEMO to related agencies. Information is broadcast to citizens in Tongan and English from the radio. Since broadcasting greatly contributes to reducing damage at times of disasters, it is necessary to clarify a code of

conduct and guidelines and support the improvement of the broadcasting capacity of media in order to provide fast and reliable disaster information. NEMO is compiling a cyclone emergency response plan in collaboration with Tonga Broadcasting Commission. Japanese experience and achievements concerning disaster broadcasting can be utilized in this field.

iv. Construction of multipurpose cyclone shelters

Tongatapu Island has many coastal lowland areas which are the most vulnerable to high tide disasters caused by tsunami and cyclones. Churches are used as emergency evacuation centers, however, it is also necessary to build emergency evacuation shelters, which can also be used for community activities at normal times. Japan has abundant experience regarding the design and construction of multipurpose cyclone shelters, and this can be effectively used in this area.

v. Compilation of infrastructure design criteria for disaster countermeasures

Tongatapu Island has many coastal lowland areas which are the most vulnerable to high tide disasters. If infrastructure facilities for preventing high tide disasters in the aftermath of rising sea level caused by climate change are planned and designed based on past natural conditions, there is concern they will be vulnerable to disaster risks. Through compiling infrastructure development and design criteria that take future climate change into account, infrastructure that is resistant to disaster risks can be designed and developed appropriately and efficiently. Concerning coastal facilities and river structures, etc., it is necessary to select the external conditions for planning and design and compile criteria that can be applied to other countries and areas with similar conditions. It is also possible to apply Japanese design guidelines, which have evolved according to the stage of economic development, according to conditions in Tonga and make use of Japanese experience in this area.

vi. Integrated hazard map preparation and coastal management capacity building

SOPAC and the Mapping Agency are jointly preparing a tsunami hazard map that assesses risk level for Tongatapu Island. Since evacuation centers, evacuation routes, risk areas, relief facilities and public facilities (police stations, hospitals, schools, churches) are common items on all hazard maps, the preparation and dissemination of integrated hazard maps that superimpose multiple risk maps (cyclones, flooding, tsunami) is essential for community disaster prevention activities. Such integrated hazard maps can also facilitate smooth responses to disasters. Support in this area is significant for promoting the effective utilization of SOPAC achievements and collaboration between traditional communities.

Moreover, as is also the case in Kiribati, coastal management is required as a non-structural countermeasure. This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management. Accordingly, it is necessary to coordinate with other agencies and departments regarding this item, and Japan can provide support based on its experience with development and utilization of coastal areas and conservation of marine environment.

vii. Dissemination and enlightenment activities

During a cyclone in 1982, 8.8% of Tongatapu Island became inundated with water from high tides. It is necessary to inform residents about the human damage and property losses resulting from inundation and sediment disasters caused by rising high wind pressure and torrential rains accompanying cyclones. Compared to structural countermeasures, dissemination and enlightenment activities are cheap, immediate and effective and thus highly necessary. It is desirable for such measures to be implemented via activities of the Tongatapu Red Cross and NGOs. Similar to early warning systems, these activities promote self-defense to disasters through utilizing traditional community ties.

viii. Urban drainage countermeasures

Since the capital city Nuku'alofa has no rivers or main drainage channels, drainage of rainwater is poor, and roadsides and low-lying areas easily become inundated. Plans are afoot to construct drainage facilities in some districts under support from international agencies, however, so far there is no comprehensive drainage construction plan for the whole city. Since climate change will lead to more intense short-term downpours in future, it is necessary to

improve drainage conditions in the capital. The outputs of international agencies can be utilized, and it is also possible to introduce advanced urban drainage technologies from Japan.

ix. High tide countermeasures

The terrain of the capital Nuku'alofa is vulnerable to high tide damage caused by cyclones. In the event where a cyclone on the scale of Isaac in 1982 occurs under conditions of raised sea level, it is forecast that 14.1% of Tongatapu Island (37.3 km^2) will become inundated. The Ministry of Public Works proposes structural countermeasures based on seawalls and tide walls, and it is desirable such works are advanced from the viewpoints of ensuring human security and urban functions in the capital.

x. Coastal national highway and bridge disaster prevention measures

Tonga comprises numerous remote islands, on which coastal roads and bridges without seawalls are damaged and in need of repairs. Accordingly, the implementation of countermeasure works on coastal trunk roads and bridges, which are vulnerable to risks from climate change disasters, is necessary for promoting tourism and maintaining the living environment of coastal residents.

xi. Information collection on disaster countermeasures and coastal erosion

Tonga consists of 169 islands scattered around ocean stretching 1,000 km from north to south and 500 km from east to west. This area is too large to conduct monitoring on individual islands; moreover, means of communications are not developed enough to allow human monitoring. Moreover, the Ministry of Land, Natural Resources and Environment and Mapping Agency are equipped with map servers and GIS technology. Therefore, it may be effective to collect information and conduct satellite image analysis following the occurrence of cyclones, flooding, earthquakes and tsunami, in order to monitor landslide sites and coastlines and utilize the data in the study, planning and design of sediment disaster and coastal erosion countermeasures. Also, considering the long-term nature of climate changes, collection of disaster information over the long term will prove useful in elucidating the actual situation and compiling countermeasures.

xii. Coastal erosion countermeasures

A project of erosion countermeasures was implemented under support from Canada and Japan, etc. on the west coast of the lagoon on Tongatapu Island. Erosion of sand beaches is manifesting on Fua'amotu Beach on the southern tip of the island and on the north coast, and the Ministry of Public Works is examining countermeasures to this. Also, since there is a lot of coastal erosion taking place on roads linking provincial cities to communities, there is need for coastal seawall measures. When it comes to implementing new works, the experience and achievements of Japan gained in Tonga before can be utilized.

Table 3-4.6 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in Tonga

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Development of alternative water source and integrated water resources management	Comprehensively manage water from sources to public supply in order to mitigate and adapt to the impacts of climate change in the water resources field.	Short term	Nationwide emergency water shortage countermeasures	In order to address acute water shortages all over the country, construct water purification facilities and additional distribution reservoirs, install portable membrane water purification facilities, and provide water trucks, etc. in the capital Nuku' alofa.	A	
			Medium to long term	Survey of groundwater reserves and monitoring of water quality	Survey long-term reserves in the groundwater lens and gauge how much water is available for development on Tongatapu and other islands in order to ensure the appropriate intake volume.	B	
			Medium to long term	Water leakage countermeasures and water saving	Gauge leakage flow and leak areas from water supply facilities, examine leakage countermeasures and promote the efficient use of limited water resources.	B	
			Medium to long term	Improvement of nationwide water supply and demand	Particularly in areas where there are reports and fears of water shortages, gauge water sources and demand for potable water and other living water via social surveys. Also, survey rainfall and river flow with a view to gauging the usable water flow and improving water supply and demand.	C	
2.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	A	○

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Organizational strengthening of the National Emergency Management Office	Establish a disaster countermeasures action standard, compile evacuation plans (dispatch of advisor), and implement functional improvement of the disaster communications network.	A	
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the smooth and prompt evacuation of residents (linkage with meteorological observation stations is needed).	A	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to building media capacity for conducting the necessary broadcasting of disasters.	A	○
			Short term	Construction of multipurpose cyclone shelters	Construct natural disaster emergency evacuation shelters, which can also be used for community activities at normal times.	A	
			Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling infrastructure development and design criteria that take climate change into account, implement infrastructure development and design appropriately and efficiently. Select a number of conditions and compile criteria that can be applied to countries and regions with similar conditions.	B	○
			Short term	Integrated hazard map preparation	Compile integrated hazard maps that superimpose various types of hazards.	B	○
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence (community disaster prevention).	B	○
			Medium to long term	Construction of urban drainage facilities	Make improvements to drainage in the capital Nuku'alofa in order to prevent the inundation of houses and roads, improve the living environment and secure the capital's functions.	B	
			Medium to long term	High tide countermeasures	Construct defenses against inundation of lowlands caused by cyclones and high tides on Tongatapu Island, and thereby mitigate damage to crops and secure road transport.	B	
			Short term	Coastal highway and bridge disaster prevention measures	Implement disaster prevention works for bridges and trunk roads, etc. that are vulnerable to disasters caused by climate change.	C	
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	C	○
			Medium to long term	Coastal erosion countermeasures	Prevent coastal erosion from washing away land, and promote the growth and preservation of tourist beaches.	C	

3-4-7 Solomon Islands

(1) Features of Support in the Solomon Islands

The Solomon Islands have experienced major disasters in recent years, for example, the tsunami of 2007 and flood and sediment disaster at the start of 2009. The country is thus sensitive to disasters, and the possibility of increased disaster risks due to climate change is further raising preparedness among people. Coastal erosion has already caused traffic interruptions in a number of places, and it has become necessary to take measures to counter this on coastal roads and to repair bridges on rivers that are prone to flooding. It is also pointed out that forestry, which is an important source of foreign currency (forestry accounts for around 10% of GDP and 70% of exports overall) is leading to the excessive cutting of trees. In these circumstances, it is important to implement non-structural countermeasures together with structural measures.

Meanwhile, in coastal lowland areas and small remote islands, salinization is advancing and carries with it the potential to cause critical water shortages for the local people. Furthermore, in the capital Honiara, excessive groundwater pumping due to population pressure has triggered salinization and there is an increasingly urgent need to deal with this.
The following paragraphs describe specific countermeasures under each direction of support in the Solomon Islands, while Table 3-4.7 summarizes climate change adaptation measures and mitigation measures under each direction of support.

(2) Integrated Water Resources Management

i. Groundwater improvement

Since the inland areas of the Solomon Islands are largely covered in thick jungle and mountains not suited to living, people tend to live in the coastal belt. However, wells in coastal areas are becoming salinized, leading to absolute shortages of drinking water during the dry season and making it necessary for the government to send out water trucks, etc.

In order to improve water shortages especially during dry spell in the dry season, an effective method is necessary to remedy the salinization of groundwater. Then it is proposed that groundwater be drawn not from wells but from infiltration gallery (intake pipes installed underground). Such a method helps prevent excessive pumping from one place and is effective for countering salinization of regional water supply.

ii. Improvement of water utilization

Provincial areas utilize rainwater, river water, spring water and groundwater for public water supply, however, due to low capacity of supply facilities and rising population, water shortages occur during dry spells. These water shortages are reaching critical levels in provincial cities and villages all over the country. Moreover, salinization triggered by excessive pumping from wells is aggravating the water shortages. As a countermeasure, water shortages can be mitigated through utilization of proper amount of water by assessing the intake volume based on analyzing the water balance. Water shortages cannot be overcome simply by installing rainwater tanks, i.e. measures that have no effect during the dry season, however, a greater effect can be gained through combining such steps with the abovementioned mitigation measures.

At the same time, it is effective to carry out dissemination and enlightenment activities encouraging communities to appropriately use water, conserve water resources (conservation of water resources recharging forests, etc.) and conduct sanitary management of water use.

(3) Meteorological Observation Capacity Building relating to Climate Change

i. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

The Environmental and Meteorological Department in the Ministry of Environment Conservation and Meteorology has 58 employees and conducts meteorological observation and forecasting, etc. There are five meteorological observation stations in the Solomon Islands and there are plans to expand the network by constructing an additional two. However,

forecasts basically comprise area weather forecasts only, and technical capacity concerning hourly detailed forecasts and localized forecasts is inadequate. The current service is unable to provide disaster forecasts, etc. It is likely that climate change will bring about changes to conventional rainfall patterns from now on, and it will be necessary to conduct forecasting under various meteorological conditions over the diverse coastal, remote islands and mountainous areas of the Solomon Islands. In addition to changing rain patterns, since localized forecasting is also important for forecasting disasters, the Solomons will need to implement localized forecasting and disaster forecasting in order to manage climate change risks in future.

Since Japan possesses abundant experience, knowledge and know-how as a country that faces numerous natural disaster risks, it can make a major contribution to the enhancement of technology in the Solomon Islands.

(4) Climate Change Risk Management

Individual project constituting Climate Risk Management is explained below:

i. Compilation of infrastructure design criteria for disaster countermeasures

In the Solomon Islands, the issue causing greatest concern is the frequent occurrence of natural disasters influenced by climate change. The Solomons possess diverse geographical conditions and natural environment ranging from mountainous islands like Guadalcanal, which contains the capital Honiara, and Auki to Rennell Island which possesses Lake Tegano, which is the largest freshwater lake in the Pacific and is registered as a World Heritage site, the Ontong Java group of small islands and so on.

However, on Guadalcanal, flooding and sediment disasters caused by torrential rains are occurring, while on Auki Island, coastal erosion has led to traffic being interrupted in the most populated parts at high tide. Also, Rennell Island is on the cyclone course, while rising sea level and salinization of water are having an adverse impact on people's lives.

As was also described in the section on PNG, it is necessary to build public facilities (infrastructure) that can respond to external forces caused by climate change such as rainfall and high tides, etc. Also, the Solomon Islands need to rebuild existing public facilities in line with economic development. It is necessary to set external force criteria that take climate change according to the service life and importance of facilities into account, and establish criteria for facility structures that can cope with climate change. Doing this will make it easier to address climate changes in future.

Moreover, since other donors hardly possess any experience in this field, Japan can offer support by making use of its unique experience and technology.

Also, since the NAPA stipulates the establishment of criteria, albeit on a limited scale, the local needs concerning this point are high.

ii. Organizational strengthening of the National Disaster Management Office

Considering that recent natural disasters have caused fatalities, organizational strengthening of the National Disaster Management Office is an important issue. The advisor who had been advised to the Office by AusAID has completed his assignment, and the Office is requesting dispatch of another advisor who possesses specific expertise in the areas of evacuation planning and emergency information communications, etc. This dispatch could be made even more effective if implemented in unison with installation of early warning systems and broadcasting capacity building.

iii. Dissemination and enlightenment activities

Raising the knowledge of residents concerning the various impacts of climate change promotes changed awareness among citizens and has the potential to bring forth autonomous climate change countermeasures on the community level. Accordingly, encouraging communities to autonomously take risk management measures with respect to climate change based on dissemination and enlightenment activities will contribute to the effective mitigation

of risks at times of disaster. As described in paragraph v., it would be highly significant to implement dissemination and enlightenment activities in tandem with community disaster prevention and disaster prevention radio broadcasting, which are other components of Japanese support here, since this would impart a huge disaster mitigation effect.

iv. Disaster broadcasting capacity building

Like PNG, the Solomon Islands are most concerned about the frequent occurrence of natural disasters influenced by climate change. In particular, there have recently been cases where extreme meteorological phenomena have triggered river flooding and sediment disasters, and it is feasible that the risk of such disasters will heighten in future. Natural disaster countermeasures triggered by climate change differ according to each area. In order to take countermeasures against disasters, it is necessary to clarify the actual state of damage and assess the effects and impact of existing measures. This involves preparing a database of facilities, surveying the actual state of disasters and identifying the effects and structural issues of the facilities concerned. Since disasters only occur rarely, it is necessary to collect survey data concerning disasters and recovery over the long term and take countermeasures based on those.

Survey work entails applying remote sensing technology to gauge the state of topographical upheavals and flood conditions. Such activities can also be utilized in environmental and forest projects. Concerning coastal erosion too, since the long-term collection of data is needed, actual conditions have not yet been clarified and the effects of countermeasures have not been fully analyzed. Thus it is necessary to regularly conduct surveys and collect information. Japan possesses ample experience concerning compilation of public facilities databases, implementation of disaster surveying and remote sensing technology, and this experience and know-how can be amply utilized here. In future, when examining long-term countermeasures, data collection will be a vital activity. Such work can make a contribution to human security and the coexistence of climate change countermeasures with sustainable development.

v. Integrated hazard map preparation and coastal management capacity building

In the Solomon Islands, which is confronted with various disaster risks such as flooding, sediment disasters, high tides and cyclones, etc., it is important to compile integrated hazard maps that enable various hazards to be comprehensively gauged. Moreover, since geographical features differ between areas, it is essential from the viewpoint of disaster countermeasures to examine what kind of disaster hazards exist. As for coastal management, this is proposed as a non-structural countermeasure for coastal erosion in the NAPA. In the NAPA, various measures such as protecting coral reefs and planting forests on coasts are proposed, and disaster prevention is cited as one element of this requiring coordination with other fields. It is also necessary to coordinate with other aid agencies, etc.

In Japan, there are numerous examples of local governments compiling integrated hazard maps, and these experiences and know-how can be amply utilized. Moreover, as was also mentioned in the sections on Kiribati and PNG, coastal management is required as a non-structural countermeasure.

This is important not only in terms of disaster management but also in terms of coastal utilization and environmental management, and support can be provided based on Japan's experience.

vi. Installation of early warning systems,

For the Solomon Islands, which comprise scattered islands of various sizes and are confronted with numerous kinds of disaster risk, the installation of early warning systems is an effective means of ensuring the safe and fast evacuation of residents and mitigating damage when disasters occur. For example, the disaster on Sasaa River caused by torrential rain at the start of 2009 caused four fatalities, however, further fatalities were avoided through evacuating residents to high ground. Concerning the emergency communications setup at times of disasters in the Solomon Islands, notification is sent from the National Disaster Management

Office to provincial disaster offices based on information from the Ministry of Environment Conservation and Meteorology. At the same time, the National Disaster Management Office conveys information to the Solomons Broadcasting Authority, which then broadcasts it to citizens via radio. However, in cases where there is no time to spare, fast means of transmiting warning are required in addition to radio broadcasts. It is necessary to install early warning systems in affected areas in order to assess the level of urgency of the disaster risk and the speed of evacuation. Currently, in the Solomon Islands it is planned to establish community disaster prevention and disaster prevention radio broadcast based on Japanese support, and installing early warning devices in unison with these measures will have a very big disaster mitigation effect and be needed for ensuring human security. Moreover, since Japan has a proven track record concerning this technology, it can fully utilize this in providing support.

vii. Coastal national highway and bridge disaster prevention measures

Coastal roads and bridges are vulnerable to disasters and have a high need for repairs. In the NAPA, this is recommended as the fourth highest priority among coastal erosion countermeasures, and this area mainly comprises construction of coastal roads and bridges Japan has a high technical level and various experiences of both successful and unsuccessful projects in this field.

Moreover, since support from other aid agencies is expected in this field, activities will need to be coordinated with this.

Table 3-4.7 List of Climate Change Adaptation Measures and Mitigation Measures and Direction of Support in the Solomon Islands

Direction of Support			Implementation Period	Countermeasure Examples		Priority	Wide Area Applicability
1.	Integrated water resources management	Comprehensively manage water from sources to public supply in order to mitigate and adapt to the impacts of climate change in the water resources field.	Short term	Groundwater improvement	Survey the conditions of salinization, and ristrict excessive concentration of groundwater pumping in order to mitigate the salinization of groundwater.	A	
			Short term	Water utilization improvement	Analyse the water balance of surface water and groundwater, etc. and improve conditions of water utilization in areas of salinization and constant water shortages. Also implement dissemination and enlightenment activities.	B	
2.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	A	○
3.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling design criteria on infrastructure development that take climate change into account, implement approproate and efficient design and development of infrastructure. When doing this, first fully consider the environmental impacts by analysing sediment balance, etc. Select common conditions and compile criteria that can be applied to countries and regions with similar conditions.	A	○
			Short term	Organizational strengthening of the National Disaster Management Office	Establishment of a disaster countermeasures action standard, compilation of evacuation plans (dispatch of advisor), and functional improvement of the disaster communications network	A	
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence (community disaster prevention)	(A) (Carry it out)	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, with a view to building media capacity for conducting the necessary broadcasting of disasters.	A	○
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	A	○
			Short term	Integrated hazard map preparation and coastal management capacity building	In addition to compiling an integrated hazard map that superimposes various types, improve management capacity with consideration given to land use and development controls, environmental conservation and utilization.	B	○
			Short term	Installation of early warning systems	Establish early warning systems in order to ensure the smooth and prompt evacuation of residents (linkage with meteorological observation stations is needed).	B	
			Short term	Coastal highway and bridge disaster prevention measures	Implement disaster prevention works for bridges and trunk roads, etc. that are vulnerable to disasters caused by climate change.	C	

3-5 Wide Area Adaptation Measures and Mitigation Measures

3-5-1 Features of Wide Area Support

In view of the efforts and experiences of other donors, countermeasures related to technology transfer and measures based on dissemination and enlightenment are largely approached as wide area activities. Moreover, considering the difficulty in implementing wide area projects, which require coordination between multiple countries, the target countries are examined in consideration of applicability to other countries.

Meanwhile, countermeasures of which implementation in all target countries leads to the collection of regional common data, has been targeted by whole region.
The following paragraphs describe wide area countermeasures and their wide area applicability under each direction of support. Description of the needs concerning each countermeasure is omitted here since they have already been discussed in the sections on each country. Moreover, Table 3-5.1 summarizes wide area climate change adaptation measures and mitigation measures under each direction of support in the Pacific region.

3-5-2 Meteorological Observation Capacity Building relating to Climate Change

i. Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology

Utilizing the framework of meteorological capacity building training being implemented under Japanese support primarily in Fiji, by implementing this in all the target countries, it will be possible to share know-how concerning meteorological observation in the region. Moreover, gauging meteorological conditions over the entire region will deepen cooperative relations between countries when implementing important climate change countermeasures.

ii. Establishment of a meteorological observation network and sharing of observation data

Conducting meteorological observations over the long term in the target area and sharing the resulting data between countries not only raises the accuracy and certainty of forecasting but is also indispensable for building drastic climate change countermeasures. In the current situation, there are some minor differences in the collection and categories of meteorological data, however, through securing the interface required for establishment and sharing of the meteorological observation network in future, it will be possible to share regional meteorological observation data on the network of the WMO (World Meteorological Organization). Doing this will also enable the Meteorological Agency in Japan to grasp meteorological data from the Pacific region in real time, thereby allowing researchers in Japan to utilize it and elucidate causes behind climate change and disasters.

Furthermore, since meteorological observation equipment has already been supplied by other donors in numerous individual projects, it is necessary to compile plans upon fully examining coordination and collaboration with other donors.

3-5-3 Climate Change Risk Management

Individual project constituting Climate Risk Management is proposed below:

i. Compilation of infrastructure design criteria for disaster countermeasures

When compiling design criteria, since it is necessary to consider various geographical, natural and social conditions, etc., the results of countermeasures are applied to countries that have similar conditions, thereby reducing the targets for examination. Concerning Nauru, although not impacted by natural disasters, since the risk of drought is extremely high, this has been included in the examination. As for PNG, since rivers are larger and the scale of sediment accumulation is far bigger than other countries in the Pacific, and conditions regarding the securing of aggregate are different, it is necessary to examine measures while also considering the possibility of single country implementation.

ii. Integrated hazard map preparation and coastal management capacity building

Concerning Nauru, the impacts of natural disasters are small, while concerning Kiribati, compound disasters are not projected. Accordingly, examination here targeted the five remaining countries.

iii. Dissemination and enlightenment activities

Community disaster prevention, which is currently under examination as a support measure of Japan, includes dissemination and enlightenment activities. Accordingly, it is desirable to implement these upon splitting the targets into two groups, i.e. the group of Vanuatu, Tonga, the Solomon Islands and Fiji, which are targeted for the said community disaster prevention support, and the group of Nauru, Kiribati, PNG, Samoa and Tuvalu, which is receiving disaster prevention radio broadcasting equipment under Japanese support. However, concerning PNG, since it is necessary to take public order into account, care is required when considering wide area implementation.

iv. Disaster broadcasting capacity building

This targets countries where plans for establishing disaster prevention radio broadcasting are implemented or the need for this is identified in the Study.

v. Establishment of coastal engineering basic courses

Coastal erosion is an inescapable issue for the Pacific island nations. In order to realize this, it is necessary for the University of the South Pacific to establish a coastal engineering basic course and hydraulic test experiment laboratory and promote widespread understanding via hydraulics and the erosion mechanism, etc. Since the university already has an intensive course on climate change for government employees, it is hoped that this new course will contribute to raising the technology of students and government workers regarding coastal erosion countermeasures. In order to realize this, it is important to utilize senior volunteers who have abundant experience in this field.

vi. Information collection on disaster countermeasures and coastal erosion

Since climate change countermeasures are conducted over a long time, disasters only occur rarely, and ongoing information collection is required in order to gauge coastal erosion conditions and countermeasures, collecting a lot of information and sharing it within the region is important for examining effective and long-term countermeasures. Moreover, in order to aggregate the outputs obtained from these and use them for elucidating the causes of climate change disasters and verifying the effectiveness of countermeasures, it is necessary to broaden the scope of targets.

Table 3-5.1 List of Wide Area Climate Change Adaptation Measures and Mitigation Measures and Direction of Support

Direction of Support			Implementation Period	Countermeasure Examples		Target country								Remarks
						Nauru	Kiribati	PNG	Vanuatu	Samoa	Tonga	Solomon	Other	
1.	Meteorological observation capacity building relating to climate change	Improve technology for measuring, analyzing and forecasting meteorology and disaster information linked to climate change	Short term	Training of meteorological and disaster forecasters, and improvement of data analysis and forecasting technology	Establish an ongoing training setup in order to develop forecasters and improve data analysis technology and forecasting technology pertaining to climate change.	○	○	○	○	○	○	○		
			Short term	Establishment of a meteorological observation network and sharing of observation data	Digitally process observation data from each country and share them on the WMO network with a view to building information for construction of fundamental climate change countermeasures.	○	○	○	○	○	○	○		
2.	Climate change risk management	Manage risks linked to climate change in order to mitigate the impacts of climate change	Short term	Compilation of infrastructure design criteria for disaster prevention	Through compiling infrastructure development and design criteria that take climate change into account, implement infrastructure development and design appropriately and efficiently. When doing this, first fully consider the environmental impacts such as the sediment balance, etc. Select a number of conditions and compile criteria that can be applied to countries and regions with similar conditions.	△	○	△		○		○		Decide on application to other countries upon assessing the outputs of this project.
			Short term	Integrated hazard map preparation and coastal management capacity building	In addition to compiling an integrated hazard map that superimposes various types, improve management capacity with consideration given to land use and development controls, environmental conservation and utilization.			○	○	○	○	○		
			Short term	Dissemination and enlightenment activities	Raise the knowledge of residents concerning the various impacts of climate change and thereby mitigate risks at times of disaster occurrence (community disaster prevention).				○		○	○	Fiji	Project support has already been implemented.
						○	○	△		○			Tuvalu	
			Short term	Disaster broadcasting capacity building	Clarify the role of broadcasting and specify a code of conduct and guidelines for broadcasting at times of disaster, and conduct the necessary broadcasting of disasters.		○	○			○	○	Tuvalu	Target countries where there is potential for linkage with Japan's grant aid radio broadcasting development
			Medium to long term	Information collection on disaster countermeasures and coastal erosion	Conduct fact-finding surveys on cyclones and other disasters and analysis on coastal topographical changes by remote sensing, etc., aggregate the findings, and elucidate the causes of disasters arising from climate change and verify the effectiveness of countermeasures. **(Collaboration project with forest and environment)**	○	○	○	○	○	○	○		
			Medium to long term	Establishment of coastal engineering basic courses	Establish a coastal engineering basic course and hydraulic test experiment facilities in the University of the South Pacific to promote understanding of the mechanisms of coastal erosion and tsunami and give education on countermeasure technologies and preparation of high tide/tsunami hazard maps.	○	○	○	○	○	○	○	○	

3-6 Important Points to Consider when Planning and Implementing Adaptation Measures and Mitigation Measures

Important points to consider when planning and implementing adaptation measures and mitigation measures are described below.

3-6-1 Water Resources Management

(a) Water sources and land problems

When planning water source development with a view to improving water supply conditions, it is sometimes difficult to acquire or lease land in cases where the development sites are located inside customary areas. Moreover, even when land inside customary sites[1] can be leased, if water source facilities (wells, etc.) are established and water is obtained, landowners sometimes demand payment for use of water, and this places a financial burden on the water supply utility. Also, landowners sometimes restrict entry to sites for the purpose of implementing maintenance activities on water intake facilities. Accordingly, it is far more desirable not to construct wells and other water intake facilities within customary areas.

(b) Financial examination of water supply expansion projects

In the Study target countries, public corporations implement the operation and maintenance of public water supply in capital cities. In cases where new water sources are developed with the goals of preventing salinization of well water and resolving water shortages, the utility cannot be sustained unless the implementing corporation can afford the water sources development cost, related facilities construction cost and operation and maintenance costs following the start of services. When making improvements to the water supply utility in response to climate change, it is first necessary to examine the financial sustainability of the improvement program.

(c) Maintenance of regional (village) water supply

Concerning water supply in regional areas (villages) it is common for the government to support the construction of facilities and local residents to autonomously operate and maintain the facilities under government guidance. In order to use village water supply facilities on an ongoing basis, maintenance by villagers is indispensable, and it is necessary to foster a sense of ownership of the facilities among them. One of the objectives of providing guidance to residents on maintenance is to encourage the utilization of NGOs in community-based activities.

(d) Survey of groundwater salinization countermeasures

Effective measures for preventing the salinization of groundwater include boosting the amount of rainwater recharged underground, building underground dams to prevent infiltration of seawater to the aquifer, limiting the ineffective discharge of groundwater to the sea and so on. Also, it is important to conduct water balance analysis and set the amount of groundwater to be developed based on the results. It is necessary to examine measures that comply with topographical and geological conditions and meteorological and hydrological conditions on the site. In areas such as Kiribati where groundwater exists as a freshwater lens, care is especially needed.

3-6-2 Meteorological Observation and Disaster Prevention

(a) Facilities maintenance taking the long-term impacts of climate change into account

When planning and constructing facilities for disaster prevention, it is necessary for them to be effective when the impacts of climate change are greatly manifested in 50 and 100 years, and it is necessary to consider the maintenance of facilities and their flexibility in responding to changing conditions. In this sense, it is necessary to build a database of facilities and devise a system for assessing and improving the effectiveness of facilities regarding various disasters. It is also necessary to pursue the utilization of locally adopted technologies and materials in maintenance.

(b) Utilization of past survey findings

Concerning coastal erosion countermeasures, long-term survey is required in order to gauge conditions and examine countermeasures. Since SOPAC has already commenced analysis on a number of islands

[1] Customary land refers to land that has no registered ownership rights but has traditionally and as a matter of custom been commonly owned by families (blood-related groups).

including Kiribati, it is necessary to address problems in collaboration with this. In order to efficiently implement climate change countermeasures, it is essential to utilize the findings of pre-existing surveys by local agencies that possess experience of similar projects in the Pacific region.

(c) Utilization of the disaster culture of target countries

The Pacific island nations have histories of disasters caused by cyclones and so on, and it is possible that these experiences are retained as disaster culture. It may be possible to realize more effective disaster countermeasures through utilizing this culture and modifying it to disasters caused by climate change.

(d) Consideration in community participation-based disaster prevention

Concerning measures where it is necessary to raise the awareness of citizens, for example, preparation of hazard maps and construction of early warning systems, etc., more effective results can be realized through taking the historical and social background of community formation into consideration.

Also, gauging and utilizing the human networks (experts, NGOs, NPOs, Red Cross, students, etc.) and know-how previously cultivated by SOPAC, SPREP and USP will develop into cooperation with the Pacific island nations.

(e) Installation of meteorological observation instruments taking maintenance into account, and utilization of forecasting findings

Concerning the establishment of meteorological observation networks and enhancement of forecasting, it is necessary to install instruments that are easy to maintain. It is particularly necessary to install observation points in remote sites such as the remote islands of Kiribati and highlands of PNG, and to give ample consideration to staff shortages among meteorological service agencies. As for forecasting, since abnormal weather conditions that cause disasters are rare occurrences, it is necessary to conduct dissemination activities so that residents utilize forecast findings and take an interest in forecasting in their everyday lives.

(f) Traveling activities by experts, etc. in wide area support

In wide area technical cooperation projects and technical training based on dispatches of long-term advisors and senior volunteers, activities mainly comprise workshops and seminars in certain countries, however, in consideration of the disparities between government agencies in terms of knowledge, experience and capability and the staff shortages in each country, it is desirable to adopt traveling guidance activities by experts as much as possible. Through establishing and offering guidance on drill tasks and acquisition targets and accepting trainees from a wide range of related agencies, information can be shared and technologies acquired more effectively.

(g) Coordination of disaster prevention networks

Adaptation measures proposed as wide area support include disaster prevention measures utilizing image analysis technology, training of meteorological and disaster forecasters and improvement of data analysis and forecasting technology, and compilation of integrated hazard maps, etc. Meanwhile, SOPAC is implementing the Pacific Disaster Risk Management Partnership Network, while the International Flood Network (IFNET) and International Centre for Water Hazard and Risk Management (ICHARM) under guidance from Japan are implementing disaster prevention activities with each country from the international perspective. Both the above networks stage international workshops and seminars every year with a view to disseminating disaster prevention technologies. Utilizing coordination between these networks is considered effective for capacity building of disaster prevention technology.

(h) Collaboration and coordination with ongoing projects

A pre-existing disaster prevention project is the meteorological forecasting and warning capacity building and firefighting and emergency setup strengthening project (grassroots technical cooperation) in Fiji. It is desirable to incorporate the meteorological and disaster prevention adaptation measures proposed here into this advance project in order to utilize, extend and sustain the achievements of the said project over a wide area.

JICA conducted ‘ Meteorological Prediction, Warning and Cyclone Disaster Prevention’ of the Third Country Training on data management of meteorological observation, utilization of early warning

including Cyclone and maintenance management of meteorological equipment for the officer of the meteorological service in 10 countries of Oceania from 2001 – 2006. Consequently, the each meteorological service can distribute the information and warning on break out, course and direction of Cyclone obtained from Fiji Meteorological Services. The training performance of the third country training is highly recognized by the participated countries. After that, Samoa, Tonga and Vanuatu requested to Japanese Government for Senior Volunteer's Expert dispatch and the experts is under the activity in each country.

APPENDIX

Appendix 1-(1) Field Survey Record: Republic of Nauru

April 1, 2009 (Wednesday)

(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi, Hiroshi Hashimoto

<Nauru Utilities Authority: Desalination plant>

Counterpart: Mr. Raphael Ribaul (Senior Water Dispatch)

- Water supply on Nauru is basically carried out by three methods: ① supply of desalinated seawater, ② supply of rainwater stored in tanks, and ③ groundwater obtained from wells. The Ministry of Utilities conducts the supply of desalinated seawater, while the other methods are implemented on an individual basis.
- Rainwater storage tanks have been supplied and distributed under Japanese assistance in recent years.
- Rainwater and desalinated seawater are used for drinking, whereas groundwater is used as miscellaneous water. During the dry season, groundwater quality declines because of higher salt content caused by salination.
- The seawater desalination plant was previously a distillation plant (treatment capacity: 1,100 tons/day, built with assistance from AusAID), however, following the breakdown of this, a reverse osmosis plant (treatment capacity 120,000 ℓ/day x 3 units = 360,000 ℓ/day, 1 unit currently broken down) has been used for the past 10 years. The plant operates 24 hours a day.
- Treated water is sent to a distribution reservoir, from where water trucks carry it to users. Water is supplied for free at the treatment plant. When water is carried by truck, it is necessary to pay a fee, and the price isA$14 per 5,600 ℓ.
- Water is supplied to 14 districts. There is one storage tank for every three households, and these receive water from the water truck. Water is supplied from the tanks to households by means of home pumps.
- The Department of Utility has two water trucks: one has capacity of 5,600 ℓ and makes 16 round trips per day (89,600 ℓ/day), and the other has capacity of 14,000 ℓ and makes five round trips per day (70,000 ℓ/day). There are also private sector water trucks.
- The Ministry of Health conducts analysis on the quality of treated water from the desalination plant.

Rainwater storage tank

Seawater desalination plant

April 2, 2009 (Thursday)

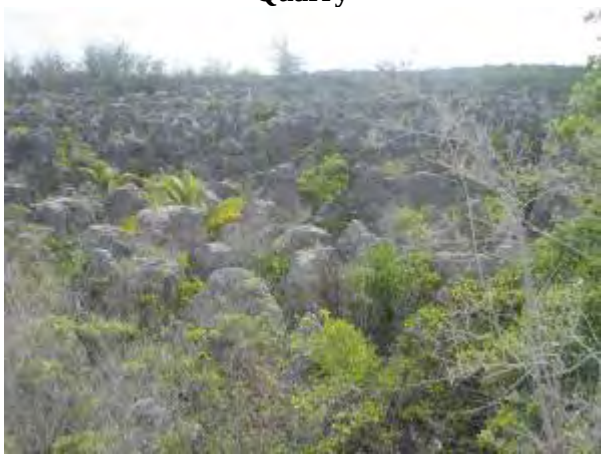
(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi, Hiroshi Hashimoto

<Nauru Rehabilitation Corporation (phosphate rock quarry)>

- The phosphate rock quarry mines a phosphate lode that is situated in coral limestone. The quarry is situated at an altitude of 20~40 m, which is high for Nauru.
- Opencast mining using heavy machinery is carried out on the quarry. The mineral rock is graded and crushed in a stone crushing plant to raise the purity level of the phosphate rock, which is then carried to the port in dedicated freight cars.
- The quarry is formed on coral limestone. The limestone has undergone dissolution by rainwater containing CO_2 over many years and consequently forms a unique terrain known as karst. The quarry surface is dominated by small spires formed by the corrosion of coral limestone, and the uneven ground surface displays a unique landscape. Currently, excavation machinery is being used to smooth out the uneven surface.
- The quarry contains a waste disposal site where waste is dumped out in the open. Abandoned cars are also left for scrap along the road.
- Groundwater observation wells have been excavated inside the quarry. Observation wells were observed at four points along the road. According to separately acquired information, there are 30 observation wells in total.

Quarry

Observation well



A type of karst terrain, the landscape is dominated by limestone steeples

The uneven ground surface is being leveled.

April 2, 2009 (Thursday)

(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi, Hiroshi Hashimoto

<Taiwan Technical Mission in the Republic of Nauru: Agricultural test site>

Counterpart: Mr. Liu Hui-Hsiung (Specialist in the Republic of Nauru)

- The government of Taiwan is providing assistance in the form of vegetable cultivation and dissemination activities. It researches types of vegetables that can be cultivated in Nauru, grows them on farms and transfers the cultivation technology to local farmers. It also educates the local people in how to cook and prepare the vegetables.
- Since sunlight is strong in Nauru and water in the soil immediately evaporates, conditions are not suited to growing vegetables. Accordingly, vegetables are cultivated away from the sun under covers. This is one example of the cultivation research work being conducted by the mission.
- The mission assembles local residents and holds workshops on vegetable cultivation methods once per month. Cooking methods are also taught in the workshops.
- The water used for growing vegetables is obtained from rainwater and water produced by desalination devices. Rainwater can only be used for three months, while desalinated water is used the rest of the time. Water is carried by water truck two times per week, however, this is costly. Initially water was taken from a nearby pond, however, the salt content of this water was too high for growing crops.

Tomato cultivation conditions

Pond near the farm: salt content is too high for the water to be used for cultivation.

Vegetable cultivation conditions

Appendix 2-(1) Field Survey Record: Republic of Kiribati

April 10, 2009 (Friday)

(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi, Hiroshi Hashimoto

<Tawara, Bairiki and Betio>

Survey was carried out over the Nippon Causeway running from Bairiki to Betio on South Tarawa Island and the coastline up to Betio.

- The Nippon Causeway suffered damage in October 2006, however, it has since mostly been repaired.
- From Bairiki to the bridge along the route, evidence of repairs can be seen in three or four parts of the slope facing out to sea.
- Judging from the repair conditions and the scattered blocks of concrete resulting from the damage, the damage has been minor and comprises wave destruction of the parapet and slope as well as scouring of the foundations.
- There are reports of sand buildup around the causeway (SOPAC: Technical Report 225, 1995), and the beach width is large on the lagoon side near to Bairiki and on the ocean and lagoon side near Betio. Moreover, since there are no dwellings nearby, the buildup is thought to have occurred in recent times.
- In the area where the causeway bridge crosses the water channel, entry and exit of tide water into and out of the lagoon have caused sand to primarily accumulate in and around the channel. This indicates shifting of the sand.
- A tide gauge has been installed at the projection of Betio Port under the South Pacific sea level and meteorological observation project of SOPAC.
- Sand accumulation was observed along the coast in the northwest of Betio. Beach has been formed up to the wave line, and vegetation grows from the shore with shrubs becoming tall trees as one moves further inland.
- According to a SOPAC report (Technical Report 179,1993), the area of Betio Island increased by 23 ha between 1944 and 1992, and this is equivalent to 20% of the island size. However, the rate of area increase is decreasing.
- The corrosion and accumulation of coral islands undergo temporary and long-term changes due to high waves, and it is necessary to gauge these conditions through ongoing observation.

Photo 1 Sand accumulation on the causeway lagoon side

Photo 2 Damage to the causeway revetment

Photo 3 Damage to the causeway revetment

Photo 4 Sand accumulation on Betio Island

April 11, 2009 (Saturday)

(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi, Hiroshi Hashimoto

<Tawara, Bairiki and Bikenibeu>

Survey was carried out on coastal damage conditions.

- The top of the breakwater at Bairiki fishing port has been destroyed almost along its entire length and it can no longer prevent the infiltration of waves. Mortar bags are also missing in some parts. It is thought that since the mortar bags were not sufficiently joined together, they have been removed by the force of waves and sand has flowed out from inside.

Photo 1 Bairiki fishing port

Photo 2 Jetty

- Oshintai Hotel faces onto the coral reef, however, the revetment foundations are partially exposed and the wall has collapsed in places. There is hardly any sand beach left at all. The hotel has been constructed jutting out from the coast.
- The coast connecting to Oshintai Hotel has projected structures such as landfills and so on, and these are thought to be affecting movements of sand.

Photo 3 Oshintai Hotel coast side (west)

Photo 4 Oshintai Hotel coast side (east)

- The coast at Bikenibeu West Primary School has two reefs to the front and one to the rear, and the revetment has been destroyed. There is some sand beach between the reefs, however, overall it is scarce. According to Mr. Beeri Ieremia, Principal of Bikenibeu West Primary School, the waves sometimes reach as high as the ground.
- The coast around King George V School was surveyed because of concern over erosion in the past. There is some sand forming a concave beach gently curving from the reefs adjoining Bikenibeu West Primary School, and it is possible that the beach is stable albeit with slight shift.

Photo 5 Bikenibeu West Primary School seen from the coast

Photo 6 King George V School coast side

- Tungaru Central Hospital has undergone renovation works partially under Japanese assistance (B/D: 1988, 1992). The hospital lies adjacent to the coast and was surveyed because the area has experienced erosion in the past (SOPAC Technical Report No.225, Project Report No.46, 2005). The sand beach is limited, however, some countermeasures such as partial construction of the seawall, etc. have been implemented.
- The top of the road running north from the airport has been damaged in the area where tides wash in and out of the coral-reef lagoon, making it impossible for vehicles to pass and forcing people to walk over a tilted bridge. There is a detour that can be used at low tide, however, this is also damaged and impassable to vehicles.

<Water resources>

- We surveyed conditions of water use in the home of a school worker along the coast in Bikenibeu. This household uses three types of water: ① government water supply, ② rainwater collected from the roof, and ③ well water. The government water supply is provided for around 4 hours per day (09:00~13:00) through water pipes. Rainwater is collected and used from a plastic tank installed on the roof. The well has been dug by hand with a diameter of 80 cm and to a depth of 2.3 m, and the groundwater level is around GL-1.7m. Distance from the coast to the well is approximately 150 m.

Photo 7 Underground well of coastal home

Photo 8 Rainwater tank

- Samples of the said three types of water were taken and analyzed. The government water was found to have electric conductivity of 0.92mS/cm, pH of 8.6 and temperature of 37℃, while the coliform group count was at least 15. The rainwater was found to have electric conductivity of 188μS/cm, pH of 7.9, temperature of 32℃ and a coliform group count of 2. Meanwhile, the well water has electric conductivity of 2.8mS/cm, pH of 8.2, temperature of 29℃ and a coliform group count of 11.
- We visited the hospital in Bikenibeu. This utilizes the government water supply and rainwater. A concrete water tank is installed in the hospital grounds: this receives water from the distribution

mainline pipe and pumps it up to an elevated tank.

Photo 9 Storage tank and elevated tank at Tungaru Central Hospital

Photo 10 Damage to the bridge linking Tanaea and Buota districts

- The bridge that connects Tanaea district to Buota district is damaged, while the water main that has been fitted to the side of the bridge girder is broken in two places. There is a storage reservoir in Bouta district, and water was previously transmitted from here to Tanaea along the broken water pipe, however, this can no longer be done.
- We visited the government water supply well located on the grounds of the airfield. There are two wells housed in a concrete box. The wells are situated on flat ground at a distance of a few hundred meters from the coastline.

Photo 11 Government water supply source (wells) – installed near the airfield

Appendix 3-(1) Field Survey Record: Independent State of Papua New Guinea

March 25, 2009 (Wednesday)
(Team members) B Group: Hiroshi Nakamura, Naoaki Nanbu, Keiji Ishibashi

<National Weather Service: meteorological observation facilities>
Counterparts: Mr. Jimmy Gomoga (Assistant Director for Forecasting & Warming), Mr. Kasis Inape (Senior Climatologist)
- The weather observatory is located on the grounds of the airfield.
- There are two receivers with diameter of around 1.5 m and these receive satellite data. One of the receivers was out of order.
- Meteorological observations are based on the WMO (World Meteorological Organization) standard of temperature, humidity, maximum and minimum temperature, rainfall, amount of evaporation, sunlight time, wind direction and wind velocity. All observation instruments are operated manually, and readings are taken and recorded by staff every hour.
- The weather observatory is in operation every day, however, it fails to record measurements frequently. At the time of the visit by the study team (March 25, 2009), the observatory could measure temperature, humidity, maximum and minimum temperature, rainfall, amount of evaporation and wind direction, however, the equipment for measuring other items was broken down.
- Balloons are used to carry out atmospheric observations. The balloons are sent up two times per day to conduct observations. Since the balloons are injected with hydrogen gas, there is a facility for performing this.
- Problems exist concerning the maintenance of equipment. Work on constructing the workshop was suspended before completion due to lack of funds 10 years ago, and it has been left untouched ever since.
- The observatory conducts data inputting by means of two dedicated computers.

Radar and balloon launching area

Ground observation instruments

Satellite receiving equipment

Equipment workshop (unfinished)

Appendix 4-(1) Field Survey Record: Republic of Vanuatu

April 5, 2009 (Sunday)

(Team members) A Group: Masatsugu Komiya, Tsuyoshi Onozato, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

April 8, 2009 (Wednesday)

(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama

<Survey record from Efete Island >

① Teouma River

- This is the largest river in Efete Island.
- The bridge was constructed under Japanese grant aid in 2005.
- The river has abundant water flow and is used as a source of living water by the local residents.
- The river downstream from the bridge sometimes experiences flooding due to heavy rainfall.
- The river immediately upstream of the bridge is twisted and there are some areas of bank slip.

Bridge constructed under Japanese grant aid

Bank slip upstream of the bridge (The houses nearby are in a dangerous position)

② Rentapao River

- As in the case of the bridge on Teouma River, the bridge here was constructed under Japanese grant aid in 2005.
- The paved road was also constructed at this time.
- The river around the bridge has abundant flow of good quality water, however, the gentle flow means that children can swim in the water here. The local residents use the river water for living purposes.

The river around the bridge is used by local residents

The road from Port Villa to the bridge is paved

③ Road conditions on the east bank

- The road on the east side has been constructed roughly 1.5 m higher than the sea surface and does not usually become covered in seawater, however, according to the local residents, waves sometimes flow over the road during cyclones.
- At a point where a small river crosses the road, there is no bridge and the road becomes impassable during heavy rain and high tide.

The road becomes impassable at high tide

The road is elevated but is sometimes covered by high waves

④ Conditions on the eastern coast

- The eastern coastline of Efete Island experiences rough waves and has many rocky stretches.
- In the limited beach areas, erosion has advanced a lot.
- The rising tide level has scoured the ground around tree roots.

The sea level has reached as high as palm tree roots

Beach erosion on the east coast

⑤ Spring water intake point on the coast (Mauta Village on the west side)

- Freshwater wells up from the seabed along the coast, and the local residents use this for living purposes.

Spring water intake point (Freshwater wells up inside Hume pipes)

Resident taking water

⑥ Former U.S. military freshwater intake point (near Port-Havannah in the northwest)

- This freshwater intake point was used by the U.S. military during WWII.
- The intake is located approximately 2 km from the coastline and is still used today by local residents.
- The water is good quality and highly transparent. Freshwater fish grow to around 20 cm in length.

Highly transparent water

The water is used for living purposes

⑦ Conditions of rainwater use (Emuwa Village in the north)

- Surface water is used for living purposes and is drawn off from the river by pipe.
- Rainwater is used for drinking.

Surface water storage tank for toilet use (Emuwa Village in the north)

Rainwater storage tank for drinking (Ditto)

Primary school rainwater storage tank for drinking (Napara Village in the north)

Police station rainwater storage tank for drinking (Ditto)

⑧ Inner sea port facilities and coastal erosion

- Waves are gentle in the inner sea between the coast and offshore island. Little coastal erosion can be seen here.
- The jetty into the inner sea is a simple stone masonry structure, and there is little major damage to it.

Jetty conditions (Emau Village in the north)

Inner sea coastline (Tanoliu Village in the northwest)

⑨ Road conditions on the north side

- Overflow walls have been constructed at the many small river crossings, however, passage by vehicles is difficult at times of heavy rain.
- Since the water flow deteriorates at the overflow walls, the road has been designed at a height of approximately 90 cm from the seabed, however, sediment has already accumulated to approximately 40 cm. There is a strong possibility of overflow occurring at times of rain.

Road is impassable at times of high water (Near Equipe Village)

Sediment accumulation can be seen upstream (Ditto)

⑩ Primary school and solar panels constructed under grassroots grant aid

- In Epao Village in the north, a primary school and home solar panels have been constructed under grassroots grant aid, and these facilities are benefitting the lifestyles of residents.

Primary school in Epao Village

Solar panel

April 8, 2009 (Wednesday)

(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama

<Survey record from Efete Island (west side and north side) >

① Spring water intake point on the coast

- Freshwater wells up from the seabed along the coast, and the local residents use this for living purposes.

Spring water intake point (Freshwater wells up inside Hume pipes)

Resident taking water

② Former U.S. military freshwater intake point (near Port-Havannah in the northwest)

- This freshwater intake point was used by the U.S. military during WWII.
- The intake is located approximately 2 km from the coastline and is still used today by local residents.
- The water quality is good and is highly transparent. Freshwater fish grow to around 20 cm in length.

Highly transparent water

The water is used for living purposes

③ Conditions of water use by ordinary households

- Surface water is used for living purposes and is drawn of from the river by pipe.
- Rainwater is used for drinking.

Surface water storage tank for toilet use

Rainwater storage tank for drinking

April 9, 2009 (Thursday)

(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Samma State Government Mr. Bure Tali (Physical Planner)

<Survey Record from Sante Island (south), Vanuatu>

① Small river crossings in the south

- Causeways have been constructed on many of the small river crossings in the south of Sante Island, however, these become impassable by cars during heavy rain.
- A number of bridges in this area were constructed under support from France in the 1970s, however, river flooding caused by heavy rains at the start of the 1990s caused trees and bridges to be washed away. Since then simple structures have been adopted.
- According to the provincial government, the water level rises by up to 2 m when the river becomes inundated.
- There used to be a clear distinction between the rainy season and dry season, however, due to the unusual climate in recent years, rain tends to fall all year round and the river becomes inundated more frequently than before.

Kerei River

Manayo River

(Blocked pipe causes water to flow over the bridge) **(Bridge constructed by France at the start of the 1990s now lies destroyed)**

② Coastal erosion in the south

- Extreme coastal erosion is occurring in the south, where seawater flows right up to coastal roadside houses and markets.
- The roots of palm trees in the area have become exposed and trees are likely to collapse in the near future.
- According to the local residents, the national highway becomes inundated at times of high tide and cyclones.

Coastal erosion in the south (Naruruna Village) (Seawater comes up to the market here)

Collapsed tree root in foreground (ditto) (Coastal sand has been washed away)

③ Coastal erosion around the road near to the state capital

- The road shoulder of the national route that runs along the coastline near the state capital has been reduced by erosion over an extensive section.
- Seawater flows from the inner sea towards the outer sea and this has formed a circular curve.
- Erosion is occurring in notches and is progressing at a gentle pace.
- According to the government workers, around 10 years ago the coastline was located approximately 2 m further out to sea than present.

Erosion encroaching on the main road (St. Michel)

Large trees collapsing due to coastal erosion (ditto)

Widespread erosion is threatening local lifestyles (ditto)

④ Conditions on Sarakata River

- Sarakata is the main river that flows through Luganville. It has abundant water flow, and the Sarakata hydropower plant, which was constructed under Japanese grant aid, is located in the upstream area.
- Sarakata Bridge (constructed in 1997 under EU support) in Luganville is located close to the river mouth close to the coast, however, bank collapse is occurring around river bends upstream of this bridge.
- Moreover, coastal and bank erosion has caused sediment to wash away downstream of the bridge, however, trees are still rooted to the ground. It is possible that these trees will collapse during future high tides.

Bank collapse upstream of Sarakata River

Rising sea level downstream of Sarakata Bridge (Scouring has occurred around tree roots)

⑤ Conditions on the southeastern coat

- Similar to the coastline in the south, coastal erosion is even occurring on the low-lying land in the southeast, where waves are relatively gentle.
- On the few sandy beaches in this area, erosion has caused sand to be washed away and the beaches are shrinking.
- Rising tide level has caused scouring around tree roots.
- There are roughly six households living in the immediate area, however, they are at risk of damage from high tides during cyclones.

Sea level has risen to the tree roots (Saraouto Village, now used as a children's camp)

Remains of U.S. military installations from WWII (Ditto)

April 9, 2009 (Thursday) 14:00~17:00

(Team members) A Group: Tsuyoshi Onosato

<Survey Record from Samma Provincial Government, Luganville City Department of Public Works)>

Counterparts: Mr.Charley Tari (Chief Director , Min. of Public Works), Peter Lulu (Rural Water Supply, Samma Provincial Government), Mr. Moly (Operation & Maintenance, Min. of Pubic Works)

Survey Contents

(1) Tour of existing facilities

- Water taken from shallow wells is transferred via three conveyance pumps to distribution tanks with capacity of 1,100m^3 and 900m^3 respectively, and approximately 2,200m^3 of water is supplied per day.
- The conveyance pump facilities were constructed in the 1950s, however, they are now badly deteriorated.
- The distribution tanks with capacity of 1,100m^3 and 900m^3 respectively are made from iron but are badly corroded.
- The conveyance pump facilities and current water source facilities are situated lower than the nearby residential areas, and they are at major risk of inundation and contamination by domestic wastewater.

- Upon surveying the quality of water at the water source (shallow wells) during the survey, electric conductivity was found to be 250uS/cm, pH was 6.9, coliform group count was 0 and the coliform count was also 0/ml.
- Sodium hypochlorite in injected on the discharge side of the conveyance pumps.
- When the facilities were inspected, a power cut meant that the conveyance pumps were not working.
- The Luganville City Department of Public Works has five employees. There is one operation controller.
- Water samples are sent to Port Vila for analysis once per month. There is no water analysis equipment in Luganville. The study team sought the daily operating logs and water quality management records, however, these materials were not provided.
- New well equipment currently being planned※1 comprises a well of roughly 30 m in length and this is situated in the Sarakata River basin. The government has already purchased a 100 meter strip of land and water use rights around the water source. The new well equipment has already undergone pump testing and the quantity and quality of water are guaranteed (the study team does not have access to the data).

※1 Concerning the water supply facilities planned by the local side (extension and rehabilitation):
In view of the background described below, the local side is planning the development of a new well, installation of additional distribution reservoirs, rehabilitation and expansion of the distribution pipe network. This project is supported by GEF, etc. and has already been incorporated as a component into the Sarakata River general water resources management plan (IWRM).
<Background of the Project>
- Current water resources (shallow wells) are at risk of contamination from domestic wastewater, etc.
- Since population increase is faster than when the facilities were first constructed, the current facilities are unable to cope with the demand for water.
- The distribution reservoirs (steel tanks) and other facilities are badly deteriorated and are in need of rehabilitation.

Photos

Current water source (shallow well)

Distribution reservoir (capacity 1,100m^3)

Requested borehole

Residual chlorine meter

Appendix 5-(1) Field Survey Record: Independent State of Samoa

March 28, 2009 (Saturday)

(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Tsuyoshi Onozato, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

<Survey record from Upolu Island (main island) eastern side>

① Apia Port

- Large ocean liners can moor at Apia Port.
- The inner bay is lined by a seawall (revetment), however, damage caused by high tides can be seen on parts of the revetment.

Full view of Apia Port and ocean liner

Revetment damage caused by high tides

② Solosolo

- The coastline has suffered high tide damage and sand has been scoured away from around tree roots.

Tree roots exposed by scouring

High tide damage encroaching the road

③ La Mafa Pass

- The pass is situated at altitude of approximately 170 m. The pass marks the water divide between the north and south of the island.
- Views are tremendous and there is high potential for development as a tourist spot.

Looking north from the pass

Looking south from the pass

④ Abulito Lake

- This is a hydropower reservoir located in the mountains in the east of Upolu.
- Since the area is mountainous and annual average rainfall is high at between 2500~7000mm, the reservoir has abundant storage capacity.

View of Abulito Lake

Verdant nearby mountains

⑤ Saitoa boat repair yard (under construction)

- Samoa Port Authority is currently building a slipway and boat repair yard on the east tip of Upolu Island.
- The repair yard will have a dome tent so that repair work can be conducted at times of rain too.
- In consideration of the environment, biodiesel is being used in the works.

Slipway and tent repair yard

Biodiesel (from Australia) for use in works

⑥ Damage to tourist spots in the southeast of Upolu Island

- The southeast coast of Upolu Island has prospered as a resort area and is visited by many foreign tourists.
- Although this area is a beach resort, no countermeasures or alarm systems have been adopted against coastal erosion and high tides.
- Palm trees damaged by high tides can be seen toppled over in some cases.

Damage in the southeast of the island

(Taufua Beachside)

Building for sea bathers in the southeast of the island

(Used by numerous foreign tourists)

⑦ Facilities for preventing high tide damage

- The coast in places is lined with stone masonry seawalls to counter high tides.
- Many settlements along the coastline road are surrounded by enclosing bunds to give protection against high tides.

Stone masonry jetty
(Water inside the jetty is a tranquil play area for children)

Housing along the coastal road (Lufilufi Village)
(Raised approximately 1.5 m above the road to give protection against high tides)

⑧ Water supply facilities in the coastal area

- Community water supply tanks (concrete tanks) have been established all over the island.
- Since Upolu Island is a volcanic island possessing numerous rivers, there are numerous springs around the coast where underflow water wells to the surface.

Concrete water storage tanks
(Example along coast)

Coastal spring (Lifilufi)
(Used as living water by village residents)

⑨ Water supply facilities in communities (Luhilufi)

- On surveying water sources in Luhilufi Village, it was found that people obtain drinking water and other lifestyle water from three springs (underflow water). The local residents do not utilize rainwater.
- One of these springs is a borehole owned by the water department. Residents pay tariffs to the water department to purchase the water. The water supply area covers the villages of Lufilufi, Faleapuna and Falema.
- The local people said that water pumped from the borehole was carried to a receiving tank (approximately 120m^3) on high ground approximately 1km away and was distributed to each household from there; however, on inspection it was found that the tank is not in use.

Bore hole installation

Receiving tank (not in use)

March 29, 2009 (Sunday)

(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

<Survey record from Upolu Island (main island) western side>

① Papapapa-tai waterfall

- This magnificent waterfall located in the center of Upolu Island has abundant water flow and a drop of approximately 150 m.
- The waterfall can be viewed in full from the road.

Papapapa-tai waterfall

Road sign (place names are easily recognizable on unified red boards)

② Conditions at the high class resort (Coconuts Beach Club) on the south coast of Upolu Island

- Luxury resorts are concentrated in the central part of the south coast of Upolu Island.
- Situated apart from the local communities, this part of the coast is a totally different environment from urban areas and is popular with tourists from Europe and America.
- The resort seawall has been built from local rocks (basalt) to give a sense of harmony with the local surroundings.

Seawall that protects the hotel main lobby

Use of local rocks providing harmony with the local environment

③ Return to Paradise beach

- This beach in the southwest of Upolu Island was used as the location for a Hollywood film (with Gary Cooper) in 1952.
- The name of the place was used in the film title. The area has no hotels and so on and is a tourist spot in its natural condition.
- The coast is protected by reefs and there is no evidence of any major coastal erosion, however, tree roots have become exposed due to scouring by high tides in some parts.

Transparent seawater and white sand beach

Signs of minor coastal erosion

④ **Secondary school constructed under Japanese grassroots grant aid**

State of Lefag and Faleaseela schools

⑤ **Project for preservation of marine biological diversity (Savaila Village)**

- Multiple donors (UNDP, GEF, UZAID, AusAID) are taking part in small-scale grant aid here.
- The implementing agency on the Samoan side is the MAF (Ministry of Agriculture and Fisheries).

Project signboard

Research facility (staff and equipment are unconfirmed)

⑥ **Ocean resources and eco tourism project**

- This is being conducted under the same donor support in the same place as the above project.
- The implementing agency on the Samoan side is the same.
- There are preserves that utilize spring water in the coastal area.

Seawall constructed in the project

Preserve utilizing spring water

⑦ **Women's society hall**

- In Savoi Village, EU support is being actively carried out and a women's society hall has been built.

Full view of the women's hall

Meeting in progress (Sunday afternoon)

⑧ **Resort hotel on the west tip**

- The resort hotel on the west tip of Savoi Island is the La Vasa Resort.
- The islands of Manono and Apolima can be seen on the opposite bank while Savoi Island can be seen in the distance.
- The resort has 10 cottage style rooms and each one faces directly onto the sea.

- The peak season is September.
- According to the employees, this area does not experience cyclone damage.
- Two large water supply tanks ($10m^3$ and approximately $30m^3$) have been installed. There is no private generator equipment.

Coastline in front of each room

Hotel water supply tanks (made in Samoa)

⑨ Emergency breakwater construction project for cyclone protection

- This World Bank project was implemented in Utualli Village in the northwest.
- The project entailed construction of a stone masonry seawall and road rehabilitation.
- Design: SMEC (Australia)

Project signboard

Stone masonry seawall
(Gentle slope in line with the coastal terrain and built higher than the road surface)

⑩ River conditions (Faleaseela Village)

- There are numerous small rivers all over Upolu Island, and the village dwellers use these for living water.
- Rest areas and waterside parks have also been prepared.
- Abundant high quality water is available.

Waterside park

Living water intake point

⑪ River in Apia City (Vaisigano River)

- The crossing bridges of Main Beach Road and Faatoia Road became inundated in 2006.
- Under the flood risk management capacity strengthening project that was conducted under support from SOPAC in 2008, flood analysis was implemented and models were verified, etc.
- Much of Apia City was inundated during the flooding of 2001. Apparently, around 5,000 residents suffered damage.
- Against the background of climate change, there is growing risk of short-term torrential rainfall and flash floods.

Upstream Faatoia bridge: the church on the right downstream bank was also flooded (in 2006).

The Beach Road bridge at the river mouth. Low-lying land at and upstream of the bridge was inundated. The coastal side is protected by a solid stone seawall.

April 1, 2009 (Tuesday)
(Team members) A Group: Masatsugu Komiya, Tsuyoshi Onozato, Takano Tomibara (JICA Samoa branch)

<Survey Record from Samoa Water Authority (SWA)>
Counterparts: Water supply: Ms. Irasa Muala (Headworks Engineer), Mr. Tamati Fau (Env. Scientist)
Sewerage: Ms. Jammie Saena (Wastewater Division Manager), Mr. Dominic Schwalger (Wastewater Engineer SWA)

Survey Contents

※ Upolu Island has three water supply facilities at Fuluasou (2 lines), Alaoa and Malololelei, and of these Fuluasou and Alaoa were visited in this survey. Also, a sewage treatment plant currently under construction was observed.

① **Fuluasou WTP, distribution reservoir**

- The facilities are divided into two lines and comprise intake equipment (with spring water as the water source), sedimentation basins, rough screen filters, slow filtration basins and chlorine sterilization equipment, etc. In one of the lines, water is directly distributed without passing through the distribution reservoir, while in the other lines, water is distributed through the reservoir (capacity 2,500 m^3).
- Although the survey was implemented immediately after heavy rainfall, the raw water quality was good and turbidity was roughly measured to be 2 degrees or less.
- Current treatment capacity is 6,000 m^3/day in the first series (constructed in 1984) and 8,000 m^3/day in the second series (constructed in 2000).
- Calcium hypochlorite is used in the chlorine sterilization facilities. The injection pump was operating, however, residual chlorine was not detected in the purified water reservoir when measured by the operator.

Slow filtration equipment

Distribution reservoir (capacity 2,500m^3)

② **ALAOA WTP**

- Current treatment capacity is approximately 12,000 m^3/day (constructed in 2000).
- The treatment flow is the same as that at Fuluasou WTP, i.e. it consists of intake equipment, sedimentation basin, rough screen filter, slow filtration basins and chlorine sterilization equipment, etc.
- The survey was implemented immediately after heavy rainfall, and the raw water turbidity was found to be high at around 10 degrees.
- The slow filtration basins have become clogged up and are unable to purify the necessary water flow due to the high turbidity level of the raw water. Accordingly, water is mixed with effluent and supplied without undergoing filtration.

Slow filtration facilities

Chlorine injection equipment

③ **Water quality control room**

- The water quality control room has pH meters, turbidity gauges, electric conductivity gauges, microorganism measuring devices and distilled water manufacturing devices, etc.
- Water quality analysis is implemented on raw water and treated water from each facility. The raw water is tested for microorganisms, while treated water is tested for residual chlorine, microorganisms, electric conductivity, residue on evaporation (TDS), turbidity and pH. Analysis is carried once per week.
- There are two staff members in charge of analysis, and they also perform other duties.

Water quality control record

Coliform measurement filter apparatus

④ **Sewage treatment facilities**

- These facilities are being constructed under assistance from the ADB. The works were commenced in January 2009.
- Batch sewage treatment facilities are under construction. The design treatment flow is approximately 1,000 m^3/day.
- The facilities under construction will conduct secondary treatment, then remove the SS content of effluent in filter cloth, and then conduct ultraviolet irradiation before discharging the water.
- The sewage system is the distribution type. The slab level of the pumping station is approximately 1

m, while that of the sewage treatment plant is approximately 8 m above sea level. Accordingly, there is concern over submergence.

Appendix 6-(1) Field Survey Record: Kingdom of Tonga

March 25, 2009 (Wednesday)
Vavau Group District Offices: Ms. Masina Tuitupou (Secretary, Governor's Office)
(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

① Neiafu Port

- The New Town Jetty Rehabilitation Wharf Project was completed in 2000 under EU support.
- This is the largest port in Vavau Province.
- It has suffered no damage from cyclones.
- The sea level has clearly risen compared to five years ago (according to interviews with the local fishermen).
- The sea level exceeds the jetty deck at high tide.
- Materials for repairing jetties on each island are shipped from this port.

Full view of Neiafu Port

Shipping of materials to outlying islands

Jetty adjoining Neiafu Port (high tide level 5 years ago)

Same place (current high tide level)

② Utulei Village (sediment discharge)

- Road drainage is poor, making passage by vehicles dangerous. There is extreme sediment discharge at times of rainfall and danger of slope collapse exists.
- Foundation soil of houses has run off, leaving the houses in a dangerous condition.
- An elementary school was constructed under the Vadu School Support Project with EU support (2008).
- A concrete water tank, which was provided by the NZ Rotary Club, has been installed within the school grounds.

House at risk of collapse due to sediment runoff

Water tank on the elementary school grounds

③ Water supply point to Utulei Village

- As the water supply source, a concrete water tank (with electric pump) has been installed approximately 1 km from the above-mentioned elementary school.
- Power supply: City low-voltage distribution network (3 phase 415V)

Water supply tank in Utulei Village

④ Pangaimotu Causeway (damage from rising sea level)

- The causeway was constructed 30 years ago under EU support.
- According to the local residents, seawater used to flow into the open channel culvert, however, due to the extreme rise in sea level in recent years, seawater sometimes rises over the top of the culvert.
- This has led to serious damage of the culvert section.

Usage of the causeway (sole access)

Corrosion of the box culvert (Seawater rises to the top of the box culvert)

⑤ Telihau Village (coastal erosion)

- Extreme erosion of the coastline has led to the roots of large trees becoming exposed.
- The erosion has reached the road shoulder, thereby reducing the road width.
- Sand drift is even occurring in the coastal resorts.

Coastal erosion

High tides have caused erosion of roads

⑥ Vaipua Bridge (Bailey Type)

- This bridge was built roughly 60 years ago during WWII, however, it has fallen into disuse due to obsolescence and corrosion (no particular effects from climate change).
- A reconstruction plan is being advanced under support from China.

Full view of bridge (prohibited passage)

The surrounding area is a scenic cove

⑦ Tefesi Village (sediment runoff)

- Due to poor road drainage and side ditch conditions, the road is badly damaged. Extreme sediment runoff occurs at times of torrential rain.
- A water supply project (concrete tank, water supply pipes and meter) has been completed under Japanese grassroots aid.

Poor road drainage conditions and damaged road surface

Water supply facilities constructed under Japanese grassroots grant aid

⑧ Halafuli Village

- A written request for a water supply project (concrete tank, water supply pipes and meters) under Japanese grassroots aid was submitted in 2006, however, this hasn't been adopted yet.
- There is an existing elevated tank, however, it isn't working due to breakdown of the existing pump.
- South Korea has supplied an engine pump as an emergency measure, however, the residents want to install an electric pump that is easier to maintain.
- Extension of the city low voltage power distribution network has been completed.
- Target beneficiaries: 8 settlements (approximately 700 people)

Existing elevated tank

Mobile phone antenna, high voltage distribution lines and other infrastructure have been installed.

⑨ Holonga Cliffs

- These are sheer cliffs at the northern tip of Baab Island.
- There are excellent views and one can see the precipitous coastline from a high place.
- This is good potential as a tourist spot, however, access is poor. Car access is possible, however, care is needed at times of rainfall.

View from the cliff volcanic cliffs

The islands often have

March 26, 2009 (Thursday)
(Local government)Ms. Masina Tuitupon (Secretary for Governor）
(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

<Tonga Vavau Group (Remote Islands) Survey Report>

① Otea Village

- The existing jetty is badly deteriorated. (It was constructed by the Tongan government some 40 years ago).
- The jetty has been excluded from the EU repair plan due to budget concerns.
- The island population is approximately 300.
- The island has an elementary school, church (Mormon) and resort hotel (British owner). It has no hospital or clinic.
- Means of communication are public (community) telephone, mobile phone and radio.
- Effects of rising sea level are not conspicuous; however, the existing jetty structure is prone to cyclone damage.

Existing jetty (extreme deterioration)

Church (which also acts as an evacuation center)

② Faleval Village

- The jetty was repaired under EU support (1995) (simple sandbag piling).
- The island population is approximately 400. This village is regarded as a core village among the 11 remote islands of this group.
- Accordingly, the island has a police station and clinic (mobile nurse service provided under EU support since the 1980s, however, there are no medical care facilities or equipment).
- Means of communication are mobile phone and radio. However, there is no VHF wireless system.
- The island has solar panels (approximately 70W, installed under support from Germany at the start of the 1990s) but these are broken.
- No effects of rising sea level were confirmed, however, the jetty has previously suffered cyclone damage.
- The earthquake alarm of March 20 (Friday) was heard on the radio. No special measures such as evacuation and so on were taken.

Jetty repaired by the EU

Clinic provided under EU support (no equipment or medical supplies)

March 25, 2009 (Wednesday)
(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

<Tonga Meteorological Agency Survey Record>

Vavau Airport Observatory

- The observatory is located adjacent to the airport.
- Equipment consists of an instrument shelter and VHF/HF radio set.
-This is an international airport, however, the runway is too short for large aircraft.

Full view of the observatory

Full view of airport terminal

March 26, 2009 (Thursday)
(Team members) A Group: Masatsugu Komiya, Tsutomu Kameyama, Masayuki Inoue (JICA Fiji Office, Wide Area Planning Surveyor)

Nukualofa Airport Observatory

- The observatory is located inside the terminal building.
- Equipment includes a rain gauge, instrument shelter, sunshine recorder, VHF/HF wireless set and evapotranspiration meter.
- The observatory is operated 24 hours a day with staff permanently assigned on a two-shift system.

Full view of the observatory

Instrument shelter, sunshine recorder, evapotranspiration meter

Appendix 7-(1) Field Survey Record: Solomon Islands

April 4, 2009 (Saturday)

(Team members) B Group: Naoaki Nanbu, Keiji Ishibashi
Counterpart: Mr. Pearson Simi (Malaita Province Disaster Manager)

<Malaita Island, Atori area>
Surveys were conducted on Kwai Island and Ngongosila Island in the bay of Atori on Malaita Island.
- Much of the bay coastline is covered in mangroves, however, erosion can be seen in breaks in the mangrove forest.
- Residents living in the eroded areas have themselves gathered and piled rocks (coral) taken from the seabed in order to prevent the erosion (Photo 2). However, the accompanying Province Disaster Manager expressed concern that this behavior could lead to further environmental problems.

Photo 1 (Adakoa Village)

Photo 2

- The bay is covered in coral and is very shallow, and since waves are broken up out to sea in areas where the coral reef is broken, waters inside the bay are very tranquil (see Photos 3 and 4). According to the local residents, waves break on the shore at times of high tide.

Photo 3

Photo 4

- Kwai Island and Ngongosila Island were formed by the accumulation of sand in the bay resulting from tidal drifts. Originally there was only one island. The split into two islands is not thought to be caused by increased sea level, however, the cause and effect relationship is still unclear.
- On Ngongosila Island, the seawater rises to around children's knee height (20 cm or so) during high tide, and this situation lasts for around one or two hours (see Photos 5 and 6).

Photo 5

Photo 6

- Due to the land shortage, some houses are built jutting out to sea (see Photo 7).
- On the two islands, banana leaves have become withered in parts and cassava does not grow back

after being cut once. It isn't clear whether or not this is due to the effects of saltwater (see Photo 8).

Photo 7 (Ngongosila Island)

Photo 8

- On Kwai Island, sand accumulation is being caused by the effects of tide and erosion is occurring in places, albeit not as bad as that seen on Ngongosila Island (see Photo 9).
- There are three wells on Kwai Island, but water from them contains salt and is bitter. The salt content becomes even higher during the dry season. The local residents use this water for living purposes, while drinking water is shipped by the government from Manou (see Photo 10).

Photo 9

Photo 10

- Some houses have installed rainwater collection tanks at their own expense, however, they don't use the water for drinking (see Photo 11).

Photo 11

Photo 12: Ngongosila Island

Photo 13: Kwai Island

- Generally speaking, there is less sand accumulation and more erosion on Ngongosila Island than Kwai Island.
- Since ample water cannot be obtained on Kwai Island, Ngongosila Island and the villages of Adakoa and Faumamanu in the bay, there are water shortages. The residents have to rely on water rations from the government for drinking water.
- Since population is densely concentrated into a narrow area on both Kwai Island and Ngongosila Island (around 500 people on islands of less than a 100 m in length), some people are intending to move to Honiara. However, since no land is available on Malaita Island on the opposite shore, the residents are unable to move there.

April 5, 2009 (Sunday)

(Team members) B Group: Naoaki Nanbu, Keiji Ishibashi
Counterpart: Mr. Pearson Simi (Malaita Province Disaster Manager)

<Malaita Island, Dala ~ Maluu>
Erosion was surveyed along the road from Dala to Maluu on Malaita Island.
- Eroded coastline (Photos 1~4): erosion is encroaching on the roadside, and the road becomes inundated and impassable at times of high tide.

Photo 1 (near Musukui)

Photo 2 (near Musukui)

Photo 3 (near Musukui)

Photo 4 (near Musukui)

- Seawater can be seen lying on the road (Photo 5). Since the coastline is low-lying land and has poor drainage, it is prone to river overflows caused by rainfall and infiltration of seawater at times of high tide. However, since the local residents can obtain drinking water from marsh water, little impact from salination can be recognized.
- Since coastal erosion occurred on a part of the coastline before, the road that was previously on the ocean side was moved further inland. Accordingly, a new marsh belt has been formed between the transferred road and coast, and there is fear that this has upset the plant ecology in the local area (only palm trees with strong resistance to seawater are remaining) (see Photo 6).

Photo 5 (near Kikin)

Photo 6 (near Maluu)

- A small community is located around the road right on the sea (see Photo 7). Since the road and settlement only lie at around 1 m above sea level, countermeasures are required. The land around houses has already been covered in sand washed up by the waves. Inundation of this area is especially severe at high tide, and trucks are often left unable to move for around two hours until the tide goes out.
- A wall has been constructed in front of the settlement to mitigate the erosion (see Photo 8). It has helped mitigate erosion, however, sand has been washed away and the wall is in danger of collapsing. Residents in the area have started moving to higher ground.

Photo 7 (near Maluu)

Photo 8 (near Maluu)

- Photo 9 shows a former abutment and the current bridge. The advance of erosion has made it necessary to conduct numerous infrastructure improvements such as bridge rebuilding and road repairs, etc. This coastal road which leads from Auki through Maluu and on to Gounatolo is a major artery into the densely populated area of Malaita Island. Supplies are transported from Honiara to Auki port, and from there to the local communities. Road maintenance is a matter of life and death for the local residents.
- Bridges on this trunk road are maintained by the residents. This is a Community Sector Project (CSP) by AusAID, whereby budget is divided between the communities which have the freedom to use it and conduct various activities they deem to be necessary. The team members witnessed repairs being made to a wooden bridge that had been damaged the previous night, and this speediness of response is made possible by allowing the communities to work autonomously.
- Mangroves are growing in front of the eroded coastline in some parts. Mangrove growth can be expected to mitigate the erosion (see Photos 10 and 11).
- Part of the mangrove forest around Maluu has been planted by NGOs. However, since no education and dissemination activities are being conducted with respect to residents, the local people don't understand the effects of forestation. In future it will be necessary to educate the local residents and have them continue planting forests (see Photo 12).

Photo 9 (near Kikin)

Photo 10 (near Maluu)

Photo 11 (near Maluu)

Photo 12 (near Maluu)

April 4, 2009 (Saturday)

(Team members) B Group Hiroshi Nakamura, Hiroshi Hashimoto

Counterparts: Mr. Herrick Savusi (Provincial Disaster Coordinator of Guadalcanal Province), Mr. Isaac Chonia (Logistic officer of Guadalcanal Province)

＜Guadalcanal Island northwest coast>

We conducted a survey of flood damage along the coastal road to the west of Honiara City in Guadalcanal.

- A number of road bridges in the section surveyed here were damaged in torrential rains that fell from the end of January to the start of February.
- Although the bridge structures have survived, connections have been washed away in many cases.
- On Vmasni River, the concrete bridges survived, however, the bridge connections and much of the natural ground on the right bank have been washed away.
- The largest flood damage was observed on Sasaa River, where flooding has caused the river course to shift significantly. Before the flooding, Sasaa River mainstream flowed along the left side of a valley plain measuring around 300 m across, however, the flooding caused multiple streams to emerge from the mainstream and to flow to the left side. These new courses converge into one stream again further downstream.
- At the point where the road crosses Sasaa River, there are now two river courses – the old course and a new one. At the surveyed point, the new river course had far greater flow than the old course.
- The flood plain of Sasaa River is scattered with large quantities of gravel and driftwood. The flood plain extends over almost the entire valley plain. The gravel mostly consists of round gravel pieces measuring no more than 10 cm in diameter, and it is inferred that gravel was washed down from the riverbed and banks by the flooding. Driftwood is also widely scattered, and it combines to form thick walls of wood in some places. Such areas can hardly be investigated even on foot.
- The mountain slopes in the furthest upstream part of Sasaa River show signs of recent slope failure, which was possibly caused by this latest flooding. However, since the sediment in the flood plain consists mainly of flood deposits rather than sand and stone debris deposits, it is judged that extremely torrential rainfall caused the river flow to increase so much that the river course overflowed in numerous places and a new river course was formed. As a result, the settlements that were located in

the path of the new river course were washed away by the flooding.
- It will be difficult to prevent such large-scale flooding through erosion control and flood protection facilities. It is better to enforce land use controls through, for example, identifying flood risk areas by hazard maps and regulating the construction of houses in such areas. It would also be effective to install the flood warning rainfall level and issue warnings when rainfall exceeds the risk level.

Bridge with collapsed connection

Vmasni River where the area around the connection on the right bank has been eroded

Remains of a former settlement and house that was washed away (Sasaa River)

New and old river course of Sasaa River: the old river course is to the right of the trees.

April 5, 2009 (Sunday)

(Team members) B Group: Hiroshi Nakamura, Hiroshi Hashimoto
Counterparts: Mr. Herrick Savusi (Provincial Disaster Coordinator of Guadalcanal Province), Mr. Isaac Chonia (Logistic officer of Guadalcanal Province), Fumiaki Samune (JICA Fiji Office planner and surveyor (environment))

<Guadalcanal Island northeast coast>
We conducted a survey of flood damage along the coastal road to the east of Honiara City in Guadalcanal.
- In the district of Ghorambau there is a settlement around 100 m away from the coast where it is reported that erosion is occurring and coconut trees are toppling over, however, the erosion doesn't seem to be very extreme judging from the surrounding coastal terrain.
- Since the hinterland is only around 1 m higher than the wave breaking point, this area is prone to high tides and high waves, however, since the distance to the opposite shore is short here, it is difficult for large waves and high tides to be generated.
- The land side of the settlement is low and thus suffers from inundation damage at times of rainfall.
-The district of Kaio has similar coastal terrain, and this area suffered from inundation damage during cyclones in 1977 and 1986 (Cyclone Nam).
- Additionally, connecting roads to bridges on the coastal road were damaged in two places, however, this is minor compared to the damage on the western coastal road. Moreover, the bridges that were constructed under Japanese grant aid are unharmed.
- We were shown this area as an example of coastal erosion, however, the distance to the opposite

shore is around 30 km and judging from the state of sediment supply from the river and conditions of the river mouth, erosion is thought to be negligible or at most minor in scale on the east coast of Honiara. However, due to the low ground height, the area is prone to damage from high tides, high waves and flooding, etc.

Conditions on the coast in Ghorambau. Fallen trees can be seen.

Conditions on the coast in Kaio. A house can be seen at the water's edge.

- The local residents have hand dug a well of 60 cm diameter and 1 m deep at a point around 100 m from the coast, and they draw groundwater from this. Apparently this well has never become salinated. However, at times of torrential rain, groundwater overflows from the well and becomes muddy. Water from this well is not used for drinking water, however, a community hand-dug well located a further 200 m or so inland is used for this purpose.

Appendix 8 Summary of Environment Impact Assessment System of Each Country

	Republic of Nauru
Environmental Act	Environment Management Act：2006
Objects of the Act	・ to co-ordinate the role of Government in relation to all environmental management processes; ・ to promote meaningful public involvement in relation to issues of environment management; ・ to ensure the observance within the Republic of Nauru of its international obligations relating to the protection of the environment; ・ to promote the concept of sustainable development in relation to the environment and natural resources of the Republic of Nauru; ・ to facilitate an assessment of the impacts on the environment of any activity likely to affect it, prior to a proposed activity taking place; and ・ to promote the understanding, management, conservation and protection of the biological diversity of the Republic of Nauru.
Content of Environment Impact Assessment System	(1) Where an Environment Officer suspects that an activity, matter or thing may be impacting upon the environment, the Officer may issue a notice requiring that any person apparently in control of or associated with the activity, matter or thing comply with any requirement specified in sub-section (2). (2) A notice issued under sub-section (1) may require all or any of the following - (a) that information be provided in relation to the activity, matter or thing to satisfy the Secretary that the environment is not thereby being adversely impacted upon; (b) that alternative activities or operating techniques be considered and employed to avoid or decrease the impact upon the environment; (c) that improvements or alterations be made in relation to the activity, matter or thing to the satisfaction of the Secretary, to avoid or decrease the impact upon the environment; and (d) any other requirement, as determined by the Secretary, to ensure that the activity, matter or thing is not adversely affecting the environment. (3) Any person served with a notice under this section shall ensure that the requirements stated in the notice are complied with within the time stipulated, and shall satisfy the Secretary, prior to the expiration of that time, that the activity, matter or thing is not adversely affecting the environment.

	Republic of Kiribati
Environmental Act	Environment Act：2007amended（1999enacted）
Objects of the Act	(a) to provide for and establish integrated systems of development control, environmental impact assessment and pollution control; (b) to prevent, control and monitor pollution; (c) to reduce risks to human health and prevent the degradation of the environment by all practical means, including the following— (i) regulating the discharge of pollutants to the air, water or land; (ii) regulating the transport, collection, treatment, storage and disposal of wastes; (iii) promoting recycling, re-use, reduction, composting and recovery of materials in an economically viable manner; and (d) protecting and conserving the natural resources threatened by human activities, particularly those resources of national and ecological significance as may be classified under the categories of terrestrial vegetation, coral, fish and marine life; (e) to comply with and give effect to regional and international conventions and obligations relating to the environment; (f) to provide for the protection, conservation and use of the environment; (g) to promote sustainable development; (h) to control, manage and regulate hazardous substances; (i) to promote the conservation and sustainable use of biological diversity; and (j) to protect, conserve and promote heritage
Content of Environment Impact Assessment System	・ A person may apply to the Principal Environment Officer for an environment licence in relation to a proposed activity ・ After receiving an application for an environment licence, the Principal Environment Officer may, in writing to the applicant— (a) grant an environment licence, subject to any reasonable conditions; (b) require the applicant to submit an environmental impact assessment report to the Principal Environment Officer; or (c) refuse to grant an environment licence. ・ The Principal Environment Officer may only grant an environment licence under subsection (1) if— (a) the possible environmental impacts of the proposed activity are well known , are not significant, will not harm area of natural, cultural or historic significance, and are not likely to be controversial; or (b) the activity is an unforeseen activity requiring immediate action in the public interest, and the need for such action outweighs the need for an environmental assessment. ・ The Principal Environment Officer must— (a) be guided by the principles of sustainable development; (b) not act inconsistently with any international obligation or agreement relating to the environment entered into by Kiribati. ・ An environmental impact assessment report must include— (a) a description of the impacts of the proposed activity; (b) the possible alternatives to the proposed activity, including the alternative of not undertaking the proposed activity; (c) mitigation measures that can be applied to minimise or prevent harm to the environment. ・ In preparing an environmental impact assessment report, the applicant must attempt to consult with any nearby or adjacent landowners; and any other person who would have an immediate interest in the activity . ・ If the Principal Environment Officer is satisfied that an environmental impact assessment report meets the requirements of this Act, the Principal Environment Officer must give notice in writing to the applicant setting out a procedure for publication adequate to bring the report to the attention of interested persons. The Principal Environment Officer may require publication of notices in newspapers and radio; the holding of public hearings; and submission of copies to public authorities or specified persons that may be interested in the proposed activity.

	Independent State of Papua New Guinea
Environmental Act	Environment Act：2000（Environmental Planning Act：1978）
Objects of the Act	(a) to promote the wise management of Papua New Guinea natural resources for the collective benefit of the whole nation and ensure renewable resources are replenished for future generations; and (b) to protect the environment while allowing for development in a way that improves the quality of life and maintains the ecological processes on which life depends; and (c) to sustain the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations, and safeguard the life-supporting capacity of air, water, land and eco-systems; and (d) to ensure that proper weight is given to both long-term and short-term social, economic, environmental and equity considerations in deciding all matters relating to environmental management, protection, restoration and enhancement; and (e) to avoid, remedy or mitigate any adverse effects of activities on the environment by regulating in an integrated, cost-effective and systematic manner, activities, products, substances and services that cause environmental harm; and (f) to require persons engaged in activities which have a harmful effect on the environment progressively to reduce or mitigate the impact of those effects as such reductions and mitigation become practicable through technology and economic developments; and (g) to allocate the costs of environmental protection and restoration equitably and in a manner that encourages responsible use of, and reduced harm to, the environment; and (h) to apply a precautionary approach to the assessment of risk of environmental harm and ensure that all aspects of environmental quality affected by environmental harm are considered in decisions relating to the environment; and (i) to regulate activities which may have a harmful effect on the environment in an open and transparent manner and ensure that consultation occurs in relation to decisions under this Act with persons and bodies who are likely to be affected by them; and (j) to provide a means for carrying into effect obligations under any international treaty or convention relating to the environment to which Papua New Guinea is a party.
Content of Environment Impact Assessment System	・ (1) For the purposes of this Part, a person carried out an activity where he carries out – (a) construction of works, land clearance, demolition, excavation or other works in relation to land or water; or (b) installation, operation or maintenance of plant or equipment; or (c) activities for the purpose of extracting or harvesting natural resources; or (d) release of contaminants to air, land or water, in connection with any of the activities specified in Paragraph (a), (b) or (c). ・ A person carries out an activity if he has effective control over that activity at the site at which the activity is carried out, and where a person has such effective control, no other person is regarded as carrying out the activity. ・ Activities that involve matters of national importance; or may result in serious environmental harm, may be prescribed as level 3 activities. ・ A person who proposes to carry out a level 2 or level 3 activity; or proposes to change the nature of a level 2 activity such that it becomes a level 3 activity, shall, in writing, register that intention with the Director at least one month prior to commencing any preparatory work in relation to the proposed activity. ・ Where the Director receives a notification of intention to carry out preparatory work in relation to a proposed level 3 activity, he shall serve a notice on the proponent named in the notification requiring the proponent to undertake an environmental impact assessment in relation to the proposed activity. ・ Where a proposed level 2 activity involves an industrial or manufacturing process which has not previously been used in Papua New Guinea; or is specifically the subject of obligations under any international treaty, convention or instrument to which Papua New Guinea has ratified; or which poses a threat of serious environmental harm, the Minister may, on recommendation of the Council, determine that the activity relates to matters of national importance and require the Director to serve a notice on the proponent requiring him to undertake environmental impact assessment in relation to the proposed activity. ・ An environmental impact assessment shall involve the following:- (a) submission of an inception report setting out the issues to be covered in the environmental impact statement; (b) submission of an environmental impact statement setting out the physical and social environmental impacts which are likely to result from the carrying out of the activity; (c) assessment and public review of the environmental impact statement; (d) acceptance of the environmental impact statement by the Director; ・ A permit may be issued subject to such conditions the Director considers are necessary or desirable, including but not limited to conditions containing requirements to do all or any of the following – (a) installation and operation of certain plant or equipment within a certain time; (b) the taking of certain action to minimise the risk of environmental harm; (c) at the cost of the permit holder, installation of monitoring equipment, carrying out a specified monitoring programme and reporting on its progress; (d) preparation and carrying out an environmental management programme; (e) provision of reports on any matter specified by the Director; (f) submission for approval and carrying out of an Environmental Improvement Plan; (g) undertaking an audit at periodic intervals; (h) preparation and lodgement of a plan for emergency response in relation to accidental release of contaminants or risk of other emergency; (i) provision of information reasonably required by the Director for the administration and enforcement of the Act; (j) lodgement of an environmental bond consistent with requirements established under Section 103; (k) conducting baseline studies or surveys and reporting the results prior to commencing operations; (l) rehabilitation of the affected area.

	Republic of Vanuatu
Environmental Act	Environment Management and Conservation Act：2002
Objects of the Act	・ to provide for the conservation, sustainable development and management of the environment of Vanuatu, and the regulation of related activities.
Content of Environment Impact Assessment System	・ All projects, proposals or development activities that impact or are likely to impact on the environment of Vanuatu; and require any license, permit or approval under any law; must comply with the provisions of this Act. ・ All projects, proposals or development activities that cause or are likely to cause significant environmental, social and/or custom impacts; or cause impacts relating to the matters listed in the following; are subject to the EIA provisions of this Part. ・ Without limiting subsection above, all projects, proposals or development activities that will do or are likely to do all or any of the following are subject to the EIA provisions of this Part: (a)affect coastal dynamics or result in coastal erosion; (b)result in the pollution of water resources; (c)affect any protected, rare, threatened or endangered species, its habitat or nesting grounds; (d)result in the contamination of land; (e)endanger public health; (f)affect important custom resources; (g)affect protected or proposed protected areas; (h)affect air quality; (i)result in the unsustainable use of renewable resources; (j)result in the introduction of foreign organisms and species; (k)result in any other activity prescribed by regulation. ・ The following projects, proposals or development activities are exempt from the requirements of this Part: (a)the construction of any single family residential building in an approved residential development area, however, such construction must be at least 30 metres from any river, stream, or from the line of mean high water spring tide of the sea; (b)any additions to an existing residential dwelling, being additions that are used only for residential purposes and are at least 30 metres from any river, stream, or from the line of mean high water spring tide; (c)the construction of traditional or custom structures fabricated from traditional materials, however, any natural rock, sand, coral, rubble or gravel that is used must not be taken from within 20 metres of the line of mean high water spring tide; (d)emergency action to protect the lives and property of people where there is not enough time to follow the requirements of this Act; (e)any other activity prescribed by regulation. ・ Any Ministry, Department, Government Agency, local government or municipal council that receives an application for any project, proposal or development activity not exempted by section above, must undertake, or have undertaken on its behalf, a preliminary EIA of that application to determine: (a)whether the project, proposal or development activity is likely to cause any environmental, social or custom impact; and (b)the significance of any identified impact; and (c)whether any proposed actions are likely to effectively mitigate, minimise, reduce or eliminate any identified significant impact. ・ If any Ministry, Department, Government Agency, local government or municipal council is the project proponent, the person who receives the application must refer the application to the Director for an assessment of the need for an EIA ・ The Ministry, Department, Government Agency, local government or municipal council that received the application must, within 10 days after the preliminary determination is made, advise the Director in writing of the determination, and may process the application without further reference to this Act if the preliminary EIA determines that: (a)no significant environmental, social or custom impacts are likely to be caused by the project, proposal or development activity; or (b)the proposed actions will effectively mitigate, minimise, reduce or eliminate any identified significant impact. ・ The Ministry, Department, Government Agency, local government or municipal council that received the application must, within 10 days after the preliminary determination is made, refer the application to the Director if the preliminary EIA determines that: (a)significant environmental, social or custom impacts are likely to be caused by the project, proposal or development activity; or (b)the proposed actions will not or are not likely to effectively mitigate, minimise, reduce or eliminate any identified significant impact. ・ The Director may, by written notice served on the relevant Ministry, Department, Government Agency, local government or municipal council, require the application for a project, proposal or development activity to be referred directly to the Director for an assessment of the need for an EIA. ・ However, the Director cannot require a direct referral unless he or she is: (a)aware of significant impacts caused by similar projects, proposals or development activities inside or outside Vanuatu; and (b)satisfied that a direct referral is more efficient having regard to the likely impact of the project, proposal or development activity.

	• The Director must inform the relevant Ministry, Department, Government Agency, local government or municipal council of the grounds for the referral in the written notice • If an application for the same project, proposal or development activity is required to be made to more than one Ministry, Department, Government Agency, local government or municipal council, the Director must be advised by each authority receiving an application and must determine which authority is to act as the co-ordinating lead agency for the purpose of undertaking the preliminary EIA. • Despite subsection above, the Department must act as the lead agency if the Director so determines and undertake the preliminary EIA. • The Director must advise the project proponent, in writing, of his or her decision on the need for an EIA within 21 days of receiving the application, unless a longer duration is agreed with the project proponent. • The Director must develop a terms of reference for any work that is to be undertaken for an EIA, including a description of the scope of work required. • In developing the terms of reference, the Director must give special consideration to the need for consultation, participation and involvement of custom landowners, chiefs and other interested parties, and may consult with the National Council of Chiefs for that purpose. • The Director must refer the terms of reference for the EIA to the project proponent for written comment within 15 days or such longer period as the Director specifies. • Within 30 days after receiving any written comments from the project proponent, the Director must make such revisions as are considered appropriate, and issue the final written terms of reference for the EIA to the project proponent. A copy of the terms of reference must be lodged in the Environmental Registry at the same time. • Unless otherwise agreed, all costs associated with the preparation of an EIA are the responsibility of the project proponent. • The project proponent must give such public notice about the project, proposal or development activity as the Director determines is appropriate in the circumstances. • Any requirement for public notice must be practical and be reasonably certain to reach any identified interested parties. • If the public notice invites written submissions, it must specify: (a)the time period by which submissions must be received; and (b)the address to which submissions must be sent. • If practicable, a copy of any public notice must be lodged by the project proponent in the Environmental Registry. • Unless otherwise agreed, all costs associated with any public notice requirement are the responsibility of the project proponent. • After receiving and reviewing the EIA report, including any submissions made under section 20, the Director may, by notice in writing, require the project proponent to correct any deficiencies and/ or provide additional information in relation to the EIA report. • Within 30 days after receiving the EIA report and any additional material required under section 21, the Director must review the report and make a recommendation on the project, proposal or development activity to the Minister. • The Director's recommendation must include any draft terms and conditions by which the application for the project, proposal or development activity can proceed. • The Director and the project proponent may, by agreement, extend any time limit under subsection (1). • The Minister must consider the Director's recommendation and, within 21 days after receiving the recommendation, make a decision on the application for the project, proposal or development activity. • The Minister must do one of the following: (a)approve the application with or without terms and conditions; (b)refer the matter back to the Director for further assessment; (c)reject the application. • The Director must advise the project proponent in writing of the Minister's decision within 14 days after the Director becomes aware of it. • If the Minister refers the matter back to the Director or rejects the application, the Minister must provide the Director with written reasons for the decision.

	Independent State of Samoa
Environmental Act	Lands, Surveys and Environment Act：1989
Objects of the Act	（Part VIII Environment and Conservation） (a) To advise the Minister on all aspects of environmental management and conservation; (b) To ensure and promote the conservation and protection of the natural resources and environment of Western Samoa; (c) To act as the advocate of environmental conservation at Government, its agencies, and other public authorities with advice on: (i) Procedures for the assessment and monitoring of environmental impacts; (ii) Pollution control and analysis of pollutants in the environment; (iii) Control and management of hazardous and potentially hazardous substances including the management of the manufacture, use, storage, transport and disposal of such substances. (d) To make recommendations to the Minister in relation to: (i) The establishment and naming of national parks and/or nature reserves; (ii) The administration, management and control of national parks and reserves including the protection, conservation and management of wild life, water resources and other marine and terrestrial ecosystems. (e) To prevent, control and correct pollution of air, water (including inland and coastal waters) and land resources and to promote litter control; (f) To carry out investigations and research relevant to the protection and conservation of natural resources and the environment; (g) To provide and promote training in the skills relevant to its functions; (h) To promote public awareness to the importance of the environment and its conservation; and (i) To do anything incidental or conducive to the performance of any of its functions.
Content of Environment Impact Assessment System	・ In 1992, after the Lands, Surveys and environment Act was enacted, National Environmental Management Strategy was formulated. ・ It adopted a holistic approach in creating cooperation between government agencies to work together towards managing the following 12 priority environment issues ・Management of population dynamics and trends ・Protection of the quality and supply of fresh water ・Protection of the sea and marine resources ・Management of waste ・Combating deforestation ・Development of appropriate land use practices ・Conservation of biological diversity ・Protection of the atmosphere ・Planning for climate change ・Preservation of traditional arts, culture and history ・Development of human resources

	Kingdom of Tonga
Environmental Act	Environmental Impact Assessment Act：2003
Objects of the Act	・ To provide for the application of environmental impact assessment to the planning of development projects within the Kingdom and matters related thereto.
Content of Environment Impact Assessment System	・ All major project shall be supported by an appropriate environmental impacts assessment, conducted as required under this act. ・ Major project assessment shall apply to all major projects as set out in the schedule and shall be conducted in accordance with the procedures set out in the regulations. ・ The minister shall determine an assessment for a major project. ・ The minister shall have regard, in making any determination under subsection above, to the effect the project is likely to have on- (a) any ecosystems of importance, especially those supporting habitats or rare, threatened, or endangered species of flora or fauna; (b) areas, landscapes, and structure of aesthetic, archaeological, cultural, historical, recreational, scenic or scientific value; (c) any land, water, sites, fishing grounds, or physical or cultural resources, or interests associate whit such areas, which are part of the heritage of the people of Tonga and which contribute to their well-being; (d) the social and the economic well-being of communities or (e) Whether any project is likely to- (I) Result in or increase pollution; (II) Result in the occurrence, or increase the chances of occurrence, of natural hazards such as soil erosion, flooding, tidal inundation, or hazardous substances; (III) Result in the introduction of species of types not previously present that might adversely affect the environment and biodiversity; (IV) Have features, the environment effect of which are not certain, and the potential impact of which is such as to warrant further investigation (V) result in the allocation or depletion of any natural and physical resources in a way or at a rate that will prevent the renewal by natural processes of the resources or will not enable an orderly transition to the other material; or (VI) Whether utility services are available and adequate for that activity. ・ Where a development proposal is submitted with an impact assessment completed under the law of a foreign country, the minister may, deem such assessment to fulfill the requirements of this act. ・ Where, in the opinion of the minister, any matters referred to is likely to occur to a significant degree, the project shall be deemed to be a major project and the prescribed procedures in the regulations shall apply. ・ All application under this act shall be in the prescribed form. ・ the minister shall determine the application for major projects within 30 working days of receipt and notify the applicant in writing of his decision. ・ Where the minister requires further information, he may notify the applicant of the requirement. ・ All major projects shall refer to the environmental assessment committee for processing. ・ there shall be established an environment assessment committee which shall consist of; (a) director of environment, who shall be chairman; (b) Solicitor general; (c) Director of health; (d) Director of planning; and (e) One member appointed by the minister, from the private sector. ・ The secretariat shall be provided by the department. ・ A quorum shall be the chairman and any 3 members. ・ The committee may co-opt persons as it deems necessary. ・ The environment assessment committee shall review and recommend to the determining authority, condition to be attached to major projects and the means by which they should be implemented and shall have the following; (a) To receive all relevant documentation relating to the application submitted for projects required to undertake major project assessment. (b) to ensure appropriate inter-departmental co-ordination is made for all major projects submitted to the environmental assessment committee; (c) to create a copy of all completed major project assessment and any report prepared on that assessment by or at the request of the secretariat; (d) to review any environmental condition recommended by the secretariat for attachment to major projects submitted to it; and (e) To recommend to the appropriate determining authority environmental conditions to be attached to major projects and the means by which these should be implemented. ・ The determining authority shall ensure that all major project proposals are to be submitted with an environmental impact assessment report. ・ No major project applicant shall proceed, unless it has satisfied the appropriate environmental impact assessment requirements under this act and approved in the prescribed form.

	Solomon Islands
Environmental Act	Environmental Act：1998
Objects of the Act	(a) to provide for and establish integrated systems of development control, environmental impact assessment and pollution control; (b) to prevent, control and monitor pollution; (c) to reduce risks to human health and prevent the degradation of the environment by all practical means, including the following – (i) regulating the discharge of pollutants to the air, water or land; (ii) regulating the transport, collection, treatment, storage and disposal of wastes; (iii) promoting recycling, re-use and recovery of materials in an economically viable manner; and (d) to comply with and give effect to regional and international conventions and obligations relating to the environment.
Content of Environment Impact Assessment System	・ In considering the grant of approval for any existing or proposed development or further expansion in any existing development, the Director, the Division and the relevant public authority shall have regard as far as practicable to the effect such development or expansion would have on the environment. ・ Development specified in the following shall for purposes of this Act be classified as prescribed development; food industries, iron and steel industries, non-metallic industries, leather, paper, textile and wood industries, fishing and marine product industry, chemical industry, tourism industry, agriculture industry, public works sector, and others. ・ Any developer who proposes to carry out any Applications for prescribed development in Solomon Islands shall make application to the Director in such form as may be approved by the Minister. ・ On receipt of the application, the Director shall within fifteen working days of such receipt advise the developer to submit - (a) a development application accompanied by a public environmental report, together with any additional requirements as notified by the Director; or (b) a development application accompanied by an environmental impact statement, together with any additional requirements as notified by the Director. ・ Any public environmental report in respect of proposed and existing prescribed development shall – (a) describe the prescribed development in summary form, including its objectives and any reasonable alternatives to it; (b) describe any aspects of the prescribed development having or likely to have a substantial or important impact on the environment; (c) describe the environment likely to be affected by the prescribed development and any reasonable alternatives to it; (d) indicate the potential or actual impact of the prescribed development on the environment and of any reasonable alternatives to the prescribed development, including any enhancement of the environment; (e) outline the reasons for choice of the prescribed development; (f) describe and assess the effectiveness of any safeguards or standards intended to be adopted or applied for the protection of the environment; (g) state any intended investigations or studies of the possible impact on the environment before the prescribed development is implemented; (h) state any intended monitoring and reporting of the impact of the prescribed development; and (i) address any further matters that the Director may specify. ・ An environmental impact statement in respect of proposed and existing prescribed development shall – (a) contain a full description of the objectives of the prescribed development; (b) analyse the need for the prescribed development; (c) indicate the consequences of not implementing or carrying out the prescribed development; (d) include adequate information and technical data adequate to allow assessment of the impact of the prescribed development on the environment; (e) examine any reasonable alternatives to the prescribed development, including alternative sites for it; (f) describe the environment that is or is likely to be affected by the prescribed development and by any reasonable alternatives to it; (g) assess the actual or potential impact on the environment of the prescribed development and of any reasonable alternatives to it, including the primary, secondary, short-term, long-term, adverse and beneficial impacts on the environment; (h) outline the reasons for the choice of the prescribed development; (i) estimate the time period of any expected impacts; (j) describe the geographic boundaries of the impacts; (k) state the methods of predicting and assessing each impact from the construction, operational and where relevant, the de-commissioning phase of an implemented development and for each alternative presented; (l) justify the prescribed development in terms of environmental, economic, culture and social considerations; (m) identify and analyse all likely impacts or consequences of implementing the prescribed development, including implications for the use and conservation of energy; (n) describe measures to prevent or reduce significant adverse impacts and enhance beneficial effects and an account of their likely success with estimated costs as appropriate; (o) describe residual impacts which cannot be mitigated or can only be mitigated partially; (p) describe proposed monitoring and reporting schemes with estimated costs as appropriate; (q) describe and assess the estimated cost-effectiveness of any safeguards or standards for the protection of the environment to be adopted or applied including its implementation, monitoring and reporting; (r) give an account of the impact on the environment of any of a series or programme of similar development (whether implemented or not) over a period of time; (s) give any sources and references of information relied on and outline any consultations with any persons made during the preparation of the report;

	(t) include a site survey report concerning National Heritage items or traditional artifacts as specified by the Director; (u) address any further matters as the Director specifies; and (v) give a clear and concise summary printed on a separate page. • The Director on being satisfied that an environmental impact statement meets the requirements of this Act shall cause such statement to be published in such manner as he considers adequate or most effective for the purpose of bringing it to the attention of all public authorities, and other persons whose interests are likely to be affected by the proposed development.