AN ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY

A CASE STUDY IN THE COOK ISLANDS

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EXECUTIVE SUMMARY

For small island countries like the Cook Islands, no issue merits more attention and action today than climate change! Climate change is the defining human development issue of this generation as it threatens to erode human rights and freedoms to make choices and lead lives the way people and countries value.

Recent devastating droughts have hit export crops and caused serious water shortages in many Pacific island countries including Federated States of Micronesia, Fiji, Marshall Islands, Papua New Guinea, Samoa and Tonga. Wave surges associated with tropical cyclones and strong winds caused flooding and inundation of productive agricultural lands in the Cook Islands and Kiribati in 2005. Cyclone Heta which hit Niue in 2004 was estimated to have cost that country about NZ$50 million which translated to about 200 years of exports. The cost of cyclones Ofa and Val that hit Samoa in 1990/91 was estimated at US440 million, which was greater than the country's average annual gross domestic product in recent years.

Commercial agriculture in the Cook Islands has suffered from the effects of droughts. Rainfall in 1997 was 32 percent below the 1971–97 average and for the first three months of 1998, rainfall was 10 percent below than in the corresponding period in 1997. As a result pawpaw volumes and export sales were lower in 1997.

Increased temperature is believed to be largely responsible for the prolific increase in populations of insects such as mosquitoes which are said to be affecting, even killing domestic pigs on one island in the Northern Group. On Mangaia, Aitutaki, Pukapuka and Mauke, taro growth has been seriously constrained due to lands becoming drier. There are also reports of coconut dieback due to insect infestation, mango fruits falling prematurely, banana trees not bearing fruits, jackfruits rotting before ripe, and custard apples not fruiting for the last three years. On Aitutaki, lands are reported to be drier and vegetables there are not growing as well as on Rarotonga.

Farmers on Rarotonga pointed out that there has been so much rain this year that irrigation has not been required. However, probably as a result of wetter conditions, some new insect pests have been discovered on taro leaves. The potato

white fly which is not a major pest in New Zealand has become a major concern for the Cook Islands. It is observed that the populations of yellow wasps have increased significantly on Pukapuka following the 2005 cyclone.

Storm surges and rising sea levels are also affecting agriculture in the Cook Islands. During a cyclone in 2005, entire taro plantation areas on Pukapuka were inundated by salt water. It took 3 years before taro could again be reintroduced to the island. Salt spray which is a major threat to agriculture in the outer islands is not such a big problem on Rarotonga where gardens are normally established on higher grounds.

Sea-level rise, salt spray and sea water intrusion have impacted on agricultural activities especially on the low-lying atolls of the Northern Group. They impede crop growth and further reduce the amount of land available for crop production. Lack of rain likewise reduces agriculture production. As experienced during cyclone "Martin", cyclone-induced strong winds and wave surges can also cause considerable damage to agriculture farms and crops.

Higher volcanic islands of the Southern Group have also experienced problems as a result of climate change. Excessive rain has resulted in the loss of some once productive agriculture lands and the flooding of plantation areas. These areas when dried after the cyclones often become boggy and difficult to cultivate.

While it is still unclear how climate change will affect fisheries and marine resources, it is believed that the long term effects of climate change including its impact on ocean circulation and sea levels will threaten fisheries and marine resources in the Cook Islands. As sea temperatures already frequently exceed the temperature tolerance level of coral species (25–29°C), it is likely that any significant increase in sea temperature in the future will result in more frequent and severe episodes of coral death and coral bleaching, thus reducing productivity of the marine areas.

Changes in the concentration and availability of fish stocks are also likely to occur should average sea temperatures continue to change in future. The recent ENSO event saw a major shift in offshore fish distribution patterns as tuna fish stocks migrated according to oceanographic surface temperatures and salinity fronts. Further global warming and circulation of the ocean would no doubt have a major effect on the distribution of the tuna fishery resources of the Cook Islands' 200-mile EEZ.

The pearl industry, the second most important economic sector for the Cook Islands also face considerable risk from cyclone damage. Cyclone "Martin" in 1997 caused damage to about 95 percent of the farmers' land-based infrastructure and to 15 percent of the cultured pearl shell. Pollution from land-based activities and from cyclone-induced flooding has resulted in poor water quality thus affecting the health and growth of cultured pearls. Elevated water temperature conditions are conducive for disease outbreaks and coral bleaching.

Increased temperatures, prolonged dry periods and high winds also cause heat stress thus affecting forest tree growth. This ultimately affects nesting-grounds for land and seabirds as well as facilitates the spreading of wind-dispersing weeds such as the balloon vine and other invasive species.

Domestic water sourced from stream catchment is limited in the Cook Islands. There is therefore a high dependence on rainfall which means the country is highly vulnerable to changing weather patterns and during times of drought. Periods of heavy rainfall too can cause problems to the water supply. Heavy downpour often causes flooding in the inland streams washing debris downstream and causing sedimentation of lagoons. This affects the health and productivity of the lagoons and reefs.

The government of the Cook Islands is already taking important steps to adapt to the adverse impacts of climate change as described here but there is still more to be done. Increasing national capacity and fostering partnership with local, regional and international communities to address the impacts of climate change will be crucial to ensuring that the Cook Islands and other PICs are better equipped to deal with the challenges brought about by climate change and climate variability.

SUMMARY OF RECOMMENDATIONS

- ~ Pay more attention to population growth and migration especially on the island of Rarotonga.
- ~ Government should strategically address a limited number of clearly identified priority adaptation actions based on the greatest needs and risks from climate change.

- Government should consider improving service delivery and communication to outer islands as explicitly clear priorities for donor-funded development projects in future.
- Efforts should be increased to ensure that plans for the re-establishment of the agriculture research station on Mauke are realized as soon as possible.
- Human resource development initiatives should continue to ensure that the Cook Islands has the necessary capacity to deal with the growing and complex issues associated with climate change.
- Encourage investment by the private sector in the processing of fruit crops into other marketable commodities such as juice and jams that have longer shelf-life and are easier and lighter to transport.
- Carry out comprehensive studies and surveys to determine how and to what extent corals and coral reefs are being affected by land-based developments and how climate change would add to existing problems.
- More studies of risk-based approaches to climate change adaptation should be undertaken coupled with increased public awareness activities to further enhance peoples' understanding of climate change in the Cook Islands.

INTRODUCTION TO THE CASE STUDY

According to FAO, the croplands, pastures and forests that occupy 60 percent of the Earth's surface are progressively being exposed to threats from increased climatic variability and, in the longer run, to climate change. Abnormal changes in air temperature and rainfall and resulting increases in frequency and intensity of droughts and flood events have long-term implications for the viability of these eco-systems.

As climate patterns change, so also do the spatial distribution of agro-ecological zones, habitats, distribution patterns of plants and diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production.

There is general awareness in the Pacific island countries about the potential impacts of climate change and extreme climatic events to the social and economic development of the Pacific islands region. However, it is not clear how or to what extent such events will affect specific countries and development sectors

within countries so that appropriate actions could be taken to adapt to any particular event on specific locations. Hence there is a need for more in-depth, site-specific analysis of prevailing conditions to ensure that adaptation plans and strategies respond to the specific needs for adaptation of the most vulnerable sites and locations.

At the 6th Meeting of Ministers of Agriculture from the South West Pacific region held in the Cook Islands from 1–3 June 2005, the Ministers, in reaffirming their commitment to enhancing food security in the region, noted the increasing need for prudent policies based on more in-depth analyses of the prevailing macroeconomic conditions and taking into account non-economic concerns. The meeting recommended that studies be carried out to assess the impact of climate variability on agriculture and food security in the region and the capacities of countries to implement international and regional agreements relating to agriculture. This recommendation was again reinforced during the 7th Meeting of Ministers (Majuro, Marshall Islands 29–31 May 2007) which amongst other things, urged FAO to pursue a study to assess the impact of climate change on agriculture and food security in the Pacific Islands region.

This study was undertaken in accordance with the above recommendations of the 6th and 7th Meetings of the Ministers of Agriculture from the Pacific Islands. A desk review of existing climate change related reports and publications on the Cook Islands was undertaken and an in-country consultation carried out in Rarotonga from 7th to 14th June 2008.

THE COOK ISLANDS

The Cook Islands comprises 15 small islands scattered over some 1.8 million sq. km of the Pacific Ocean between Samoa and Tonga on the West and French Polynesia on the East. The islands are located between latitudes 9° and 22° South and longitudes 157° and 166° West. The islands are divided geographically and politically along a line between Palmerston and Suwarrow into a Northern Group (six islands) and a Southern Group (nine islands).

The Cook Islands has a total land area of 240 sq. km, with over 88 percent (214.8 sq. km) of the land area in the Southern Group.

Five different island systems found in the Pacific Basin are represented in the Cook Islands: high volcanic islands; low volcanic islands surrounded by a raised reef platform or *makatea*; volcanic partially submerged with a large atoll-type lagoon or almost-atoll islands; true atolls; and sand-cays.

The low-lying islands have a height range, above mean sea level, of 5–9 meters. Rarotonga is both the largest (67.2 sq. km) and highest island (625 m above sea level). With the exception of Manuae, Takutea and Suwarrow, all islands of the Cook Islands are inhabited.

GOVERNANCE

The Cook Islands became a British Protectorate in 1888 and was administered by New Zealand; it was annexed to New Zealand in 1901. The Cook Islands achieved self-government in 1965. Under its Constitution (1965), the Cook Islands has complete control over its own affairs, in free association with New Zealand. The Cook Islands can, at any time, move to full independence by a unilateral act if it so desires.

Executive authority is vested in Queen Elizabeth II, who is Head of State, and exercised through the Queen's Representative. Executive government is carried out by a Cabinet of the Prime Minister and up to eight Cabinet Ministers including a Deputy to the Prime Minister. The Cabinet is collectively responsible to a unicameral Parliament, presided over by a Speaker and is made up of 24 members elected by popular vote to serve four-year terms. The House of Arikis comprises up to 15 members; it can advise the Government but has no legislative powers.

Except Rarotonga, each of the main islands has an elected Island Council, with the Ariki as ex-officio members, and a Government Representative appointed by Cabinet.

THE PHYSICAL AND NATURAL ENVIRONMENT OF THE COOK ISLANDS

CLIMATE

The Cook Islands have a pleasant warm and sunny climate with an average relative humidity of 84 percent. Average monthly temperature for the Northern Group is 28°C with little diurnal or inter-seasonable variation. The Southern Group

however is characterized by a wider temperature range with greater inter-seasonal variation. Temperature for the entire group ranges between 21 and 28°C but extremes have been recorded.

There is a marked season in the rainfall regime with a dray season consisting of only a third of the 2000 mm of rainfall occurs (May to October) while the other two-thirds occurs during the wet season (November to April). The wet season is also the cyclone season associated with the easterly shift of the South Pacific Convergence Zone (SPCZ) over the country.

The movement of the SPCZ between the Northern and Southern Groups is an important phenomenon for influencing weather patterns of the Cook Islands. The SPCZ is a convergence zone of air between the equatorial easterly winds and the south easterly trade-winds. The SPCZ varies from month to month, and the weather in the Southern Group is largely dependent on its position and intensity.

Associate with this movement are the seasonal variations which are much more noticeable in the Southern Group. Between May and October (dry season), the SPCZ is generally to the north of the Group with dry south-easterly winds prevailing, causing cooler temperatures. From November to April (wet season) the SPCZ may lie over the Group, causing unsettled weather and warmer temperatures with higher humidity and heavy rain.

SOILS

The soils of the atolls of the Northern Group are derived from coralline material, highly porous and inherently infertile. They are only capable of supporting coconut and pandanus and, when sufficient humus has built up (generally in marsh depressions), pit taro (*pulaka*).

The soils of the Southern Group are basically derived from volcanics and therefore more fertile and suitable for a wide range of agricultural production. Aitutaki and Rarotonga provide the larger areas of arable soil.

On Rarotonga, swamps are located at the toe of the foothills and behind the coastal ridge. On the *makatea* islands, the swamps extend from the inner foot of the *makatea*. These swamps are generally planted with taro (*Colocasia esculenta*).

Sediment from the deeply weathered clay soils of the interiors of Atiu, Mitiaro and Mauke enriches the fertile arable lowlands and taro producing

swamplands. On Mangaia and Atiu, some areas of steeper uplands formerly used for pineapple production are actively eroding as a result of poor cultivation and drainage practices.

WATER

As coral atolls, islands in the Northern Group are without surface water and dependent for supplies on the fragile fresh water lens which are subject to rapid depletion, salt intrusion and other pollution. Individual homes traditionally depend on rainwater stored in small containers however, with the introduction of larger tanks most dwellings now have 4 500 liters capacity ferro-cement rainwater tanks, while 45 000 liters communal rainwater tanks have been constructed near or under large public buildings.

The volcanic islands of the Southern Group are well supplied with good quality drinking water and have no major problems during normal climatic conditions. On Rarotonga and Mangaia, the springs and streams within the catchment valleys provide a good source of potable water and these have already been tapped using filter bed intake systems. On Rarotonga, water is piped from the stream catchments into the main reticulation system, serving the majority of households.

On other volcanic islands of the Southern Group, adequate underground aquifers and pumping facilities have been provided under the government's water development programmes. The undulating terrain of these islands makes gravity-fed reticulation possible, with pumping systems used to supply settlements in flat or elevated areas.

It has been established that there is a lot of water wastage on the islands especially as a result of small-scale subsistence and commercial farming activities around homes. This accounts for about 200 liters per day, over three times more than that used by expatriate homes.

ENERGY

Electricity is supplied to most inhabited islands. Electric generators are all diesel-powered, the fuel being imported at great cost to foreign exchange. Photovoltaic systems have been introduced to Mitiaro, Pukapuka and Palmerston

and the Cook Islands government is seeking to promote the wider use of solar and other alternative energy sources in an effort to reduce dependence on imported fuel.

MINERALS

The Cook Islands is not endowed with land-based minerals but have great potential in deep sea nodule minerals that are rich in cobalt. Scientific expeditions have revealed the quantities of manganese nodules on the sea beds of the islands north of Rarotonga.

In the Cook Islands, the term mineral is mainly applied to sand deposits of the beaches or materials from quarry. Extensive mining of beach deposits has been going on for over fifty years and is widely believed to be a major contributor to coastal area retreat on Rarotonga. Quarried basalts on Rarotonga, and limestone on Aitutaki and Mangaia have provided metal for road-building and construction purposes for years.

BIOLOGICAL FEATURES

The islands of the Cook Islands are remotely located on the lower end of a biological diversity gradient which diminishes with distance from the continental land masses and the equator; hence they have little diversity in flora, fauna and marine life in comparison to their northern and eastern neighbors.

The Cook Islands is near the center of the tropical South Pacific, which is well along the eastward decline in biodiversity as one moves from Indonesia and Papua New Guinea eastward through Fiji, Samoa and Tonga, to the Cook Islands and beyond. Furthermore, the oceanic gap between Samoa and Tonga, about 1 000 km, is a very significant barrier to the dispersal of plants and animals, both terrestrial and marine.

FLORA

The Cook Islands has an endemism rate of about 10 percent. Of the 173 flowering plants recorded, 18 are endemic. There are many introduced plant species in the Cook Islands, many of which fall into the food plants and ornamental plant categories. However, there are also a large number of plants introduced to improve

soil for agricultural production. Grasses are an important feature. There are an estimated 60 species, of which 12 are pre-European (native and aboriginal) and 48 are modern grasses introduced during post-European contact.

Although much alteration of the island has taken place, the rugged interior of Rarotonga remains intact. It supports about 105 native species and 230 introduced flowering plants. Of the 105 native plants, 10 are Polynesian endemics and 15 are unique to Rarotonga. In addition to flowering plants, the mountains support about 88 species of ferns, including the giant angiosperms or ana'e (*Nagiopteris longifolia*) and the Disc filmy-fern (*Trichomanes tahitensis*). Of these, seven are Polynesian endemics, one is a Cook Island endemic and four are unique to Rarotonga.

The Rarotonga cloud forest contains the most restricted plant community on Rarotonga and also contains most species unique to the Cook Islands. This community is situated at and above 400 meters and covers less than 3 percent of the total land area of Rarotonga. It supports nine species of flowering plants not found in other communities on Rarotonga, four of which are not found anywhere else in the world.

FAUNA

Terrestrial mammals are restricted to introduced species such as pigs, dogs and cats. The most easterly known occurrence of the Tongan flying fox (a fruit bat) is in the Cook Islands; it is found only on Rarotonga and Mangaia. Three species of rats are also found and pose a threat to the survival of the endemic Rarotonga fly-catcher and some agricultural crops.

A number of crabs are found in the Cook Islands including the butcher land crab or *tupa* (*Cardisoma carniflex*) and the coconut crab or *unga kaveu* (*Birgus latro*). The *tupa* is a local food source and has been heavily exploited, while the coconut crab, which is a gastronomic delicacy, has become extremely scarce on islands with larger populations.

A total of eleven seabirds species are found in the Cook Islands nesting mainly on atolls and sand cays. On land, there are four native birds found in small numbers in the inland mountains of Rarotonga: the Rarotonga starling (*Aplonis cinerascens*), the Cook Islands fruit-dove (*Ptilinopsis rarotongensis*), the Pacific pigeon (*Dacula pacifica*) and the rarer Rarotonga fly-catcher (*Pomare dimidata*). The introduced Indian myna is now the dominant bird on almost all the islands in the Cook Islands.

MARINE RESOURCES

All of the Cook Islands feature coral formations, frequently fringing and lagoon reefs. In the Southern Group of islands, windward and leeward atoll reefs are restricted to Palmerston and Manuae, while barrier reefs occur only in Aitutaki.

Coral reefs and lagoon resources provide a very important food source for many Cook Islanders, most notably in the Northern Group and now, to a lesser extent the Southern Group. With the high dependence on imported food and the change in lifestyle in the Southern Group, not to mention the degraded reef and lagoon environment, particularly on Rarotonga, harvest of reef food is becoming less frequent.

Tridacna (*Tridacna maxima*) or paua is the most popular shellfish harvested, with the introduced trochus (*Trochus niloticus*) becoming increasingly popular as a food source for locals on Aitutaki. Trochus has also made an important contribution to the income earnings of Aitutakians and has in recent years been established in Palmerston, Manuae and Suwarrow. The black lip pearl oyster or parau (*Pinctada margaritifera*) of the Northern Group, particularly Manihiki and Penrhyn is harvested for food and income. The pearl industry was valued as high as $18 million prior to 2002 but has since declined to about $2.3 million annually[1].

SOCIAL AND CULTURAL SETTING

THE PEOPLE

Cook Islanders are Maori and share a bond of history and culture with the indigenous people of French Polynesia and New Zealand. Cook Islanders are also citizens of New Zealand. Cook Island Maori constitute 87.7 percent of the population with part Cook Island Maori and other ethnic groups making up the balance. The population of Cook Islanders in New Zealand is said to exceed 20 000, greater than the home population. Most Cook Islanders when migrating abroad go to New Zealand or Australia.

1 National Sustainable Development Plan, 2007–2010.

POPULATION TRENDS

The population of the Cook Islands was recorded at 18 552 during the 1991 census. Of this number, 12.3 percent lived in the Northern Group and 87.6 in the Southern Group, with 59.2 percent of these living on Rarotonga. Figures from the 1991 census shows for the first time since 1971, an increase in the population by 5.55 percent. The population again fell by 5.6 percent between 1996 and 2001 due to out-migration but increased again within the five years leading to the latest census. The latest census of 2006 shows that the population of the Cook Islands has reached 19 569 people, an increase of 8.6 percent since the last census in 2001[2]. It was estimated that the total population of the Cook Islands will reach 24 300 by the end of December 2007[3].

Internal migration is an important feature of the demography of the Cook Islands, with the 2006 census showing a 24.2 percent decrease in the population of the Northern Group and except for Rarotonga, a slight increase of 0.5 percent in population for the Southern Group.

The islands of Rarotonga, Aitutaki and Palmerston experienced increases between 2001 and 2006 while the rest of the islands experienced decline ranging from 31.8 percent in Manihiki to 1.4 percent in Nassau.

Rarotonga remains the most populous island in the Cook Islands with 72.3 percent of the population residing there. The rest of the Southern Group accounts for 20.6 percent of the population while the Northern Group has 7.1 percent of total population. This population distribution is relatively similar to that during the 1991 census.

Based on data from the 2001 census[4], the 0–14 age group accounted for 34.1 percent of the population, 15–64 age group 59.5 percent and 65 years and over, 6.4 percent. The average life expectancy for the Cook Islands is 71 years.

2 Cook Islands Statistical Bulletin. Census of Population and Dwellings 2006. Preliminary Results.
3 Statistics Cook Islands. Quarterly Statistical Bulletin, December 2007.
4 In Pacific Island Magazine, January/February 2008.

TABLE 1: **TOTAL POPULATION OF RAROTONGA AND ISLAND GROUPS**[5]

CENSUS YEAR	RAROTONGA	SOUTHERN GROUP	NORTHERN GROUP	COOK ISLANDS
1902	2 060	4 289	1 864	8 213
1906	2 441	4 160	1 917	8 518
1911	2 759	4 312	1 584	8 655
1916	3 064	4 146	1 595	8 805
1921	3 503	4 308	1 648	9 459
1926	3 936	4 482	1 664	10 082
1936	5 054	5 279	1 913	12 246
1945	5 573	6 441	2 074	14 088
1951	6 048	6 744	2 287	15 079
1956	7 212	6 771	2 697	16 680
1961	8 676	6 921	2 781	18 378
1966	9 971	6 973	2 303	19 247
1971	11 478	7 549	2 295	21 322
1976	9 802	6 336	1 988	18 126
1981	9 530	5 912	2 301	17 743
1986	9 826	5 607	2 181	17 614
1991	10 886	5 512	2 219	18 617
1996	11 225	5 473	2 405	19 103
2001	12 188	4 061	1 778	18 027
2006*	14 153	4 095	1 321	19 569

*Preliminary result, subject to change

5 Adapted from Cook Islands Statistical Bulletin: Cook Islands Census of Population and Dwellings 2006. Preliminary Results.

THE CULTURE

The people of the Cook Islands are acutely aware of their cultural heritage, and traditional customs and practices pervade their daily life-style. Even though society has been much influenced and altered by external religious beliefs, life-style and cash economy, their adoption of aspects of Western culture is nevertheless greatly dependent on their conformity with traditional culture which dictates that anything done by a person or a clan must be in harmony with nature. The traditional culture of the Cook Islands people can be regarded as still alive but endangered.

While a number of cultural changes have taken place and will continue to do so, the oral traditions of the people, many of the customs surrounding the main phases of life – birth, marriage and death – and the social institutions of the *marae* (meeting place), *koutu* (investiture sites) and *paepae* (house sites) still persist, although some more strongly than others. Another widely used and important custom is the traditional calendar which is used for making decisions on family planning, fishing for certain species, agricultural practices, location of structures and other matters. Also retaining in importance is the practice of traditional Maori medicine, although this is more as an adjunct to European medicine rather than as an alternative.

LAND OWNERSHIP

Like most other PICs, all the lands of the Cook Islands traditionally belong to the native inhabitants of the islands. In accordance with the land court system, lands are now classified into Crown Land (land acquired by government); Customary Land (land held by natives or descendants of the natives); or Freehold Land (customary land held by individuals through lease, license, occupation or court order).

Customary land is inherited unilaterally by all members of the family which means that a large number of people have ownership rights to a small section of land. This multiple ownership results in land titles becoming extremely fragmented.

Freehold land, which is owned by one or more individuals have allowed individuals to develop land although a large number of land development have been undertaken by extended families and are mainly of a subsistence nature.

Land administration is carried out through the procedures of the land court for most of the islands, with the lands of Mangaia, Mitiaro and Pukapuka still under customary control.

EDUCATION

Although there are privately owned primary and secondary schools in the Cook Islands, most schools are owned an operated by government. A review of the education system was carried out by government in 1989. Highlighted in the review report was the establishment of school committees to run the affairs of the schools; a move to strengthen and improve the capability of Tereora College to make it a technical training center for the Cook Islands; and improving major primary schools to be able to support up to New Zealand School Certificate Fifth Form classes.

Despite its good intentions, budgetary allocations have not been adequate to cope with the desired changes to the system.

RELIGION

The Cook Islands people have always had a strong religious fervor. Since the arrival of the Christian missionaries, this fervor has been directed to various denominations of the Christian faith to which over 90 percent of the population belong. The churches are the nuclei for community work programmes and activities in the Cook Islands.

ECONOMY

The economy of the Cook Islands is characterized by a large number and hence high cost of imports and a proportionately small number and low value of exports. Primary production principally in agriculture, fisheries and quarrying once dominated the economy but there has been a strong move towards a service-oriented economy to cater to the demands of a growing tourism industry in recent years.

Tourism is the major industry in the Cook Islands with more than 30 000 visitors each year. The industry is estimated to be worth more than $30 million annually to the economy thus tourism will remain a major industry for the Cook

Islands in terms of foreign exchange earnings for as long as the special features of the country (its people, scenery and unspoilt environment) which attracts the tourists are not destroyed.

Since 1985, the cultivated pearl industry in the Northern Group has become a significant contributor to the economy of the Cook Islands. In 1990, exports of cultured-pearly fetched more than $4 million making it a highly successful resource development project for the country.

The economy of the Cook Islands is characterized by the following numbers:

- Gross Domestic Product: NZ$280.2 million (US$215 million) (2006 current market prices);
- Gross Domestic Product per capita: NZ$13 158 (US$10 137) (2006);
- Gross Domestic Product growth rate: 2.5 percent (2007, ADB);
- inflation rate: 1.82 percent (September 2007);
- unemployment rate: 13.1 percent (2005);
- unemployment rate: 13.1 percent (2005);
- national budget: NZ$108.6 million (US$83 million), (2007–08);
- aid: NZ$21.2 million (US$163 million), (according to 2007–08 budget estimates).

Although the ADB had forecasted a 2.5 percent growth in the Cook Islands economy for 2007, tourism which accounts for half the gross domestic product is particularly vulnerable to the risks posed by inadequate and aging infrastructure. The potential of a seabed nodule mining industry is being investigated with Cabinet setting up a committee to review expressions of interest in the resource and establish terms and conditions for engagement with potential developers. Government has been advised by the International Finance Corporation to proceed with caution on this particular matter.

ECONOMIC DEVELOPMENT AND POLICIES

The Cook Islands government development policies lay emphasis on infrastructure improvements which provides the base for sound economic development. The first ever National Development Plan for the Cook Islands had as its main objective the financing by the public sector of the infrastructure requirements which would support and foster a private sector economy. Port and wharf facilities, airstrips and

roads were constructed, and water supply, energy, medical and communication services established and upgraded. At the same time, new technology has been transferred to the country and the level of internal and external financial services greatly developed. As a consequence, the economy has experienced several years of sound private sector-led growth.

Sector GDP showed a sharp decline in agriculture and fishing from 25.5 percent of GDP in 1982 to less than 18 percent in 1990. Over the same period, the finance and business services sector increased from 2.4 percent to 12 percent, attributable partly to the operation of the off-shore financial center. Wholesale and retail trade and restaurants and hotels remained relatively steady over the 1982–1990 period. The service sector, including government services made up almost 77 percent of GDP in 1990, compared to 65 percent in 1982.

LABOR AND EMPLOYMENT

Some significant changes have occurred in the structure of employment in the Cook Islands in the past 25 years. Of particular significance is the decline in employment in the primary sector particularly on Rarotonga since the early 1980's and the corresponding sharp increase employment in the services sector.

Traditionally, the Cook Islanders followed a subsistence way of living, however the agricultural labor force has been declining over the years, offset by a major growth in tourism and related services.

Compared to many other PICs, unemployment has not been considered a major social issue in the Cook Islands, however with unemployment levels now reaching more than 10 percent and reduced employment opportunities in the depressed economic circumstances of New Zealand and Australia, migration of the young-adult age group could be reduced thereby causing further increase in unemployment in the Cook Islands.

INTERNATIONAL TRADE

Total imports for 1990 were valued at $83.6 million with exports estimated at $8.2 million. The main commodities imported during that year were food (20.6 percent), fuel (11.7 percent), manufactured goods (33.5 percent), and machinery and vehicles (18.0 percent). New Zealand has continued to supply between 50 and

60 percent of imports since 1978 while imports from other nations particularly in Asia and to a lesser extent the United States and Fiji are increasing.

Exports have been heavily dependent on agricultural commodities and hence subject to the severe fluctuations in international market prices. Export values varied widely over the period 1986–1990 from a peak of $11.9 million in 1987 to a period low of $4.7 million in 1989. In 1990, exports were valued at $8.2 million.

The export pattern has been changing over the years with the most marked change in the manufactured goods sector. During the 1986–1990 period, the export of basic manufactures increased 100-fold to almost $4.4 million, accompanied by a ten-fold decrease in the export of miscellaneous manufactured goods including clothing, footwear and handicrafts. In 2007, fisheries and pearl exports accounted for almost ninety percent (90 percent) the value of all exports from the Cook Islands (see Table 2).

TABLE 2: **VALUE OF PRINCIPAL EXPORTS OF THE COOK ISLANDS ('000)**

Period	Total Exports	Pawpaws	Taro	Live Fish	Fish Fresh or chilled	Pearls	Pearl Shells	Clothing	Maire	Other Exports
2003	14 588	620	-	281	8 258	2 843	49	229	33	2 275
2004	10 771	122	7	135	2 898	3 177	37	204	37	4 154
2005	7 417	32	-	111	3 381	1 646	3	176	18	2 050
2006	5 420	263	-	141	1 066	2 044	3	136	30	1 737
2007	6 951	117	-	54	3 141	2 109	218	50	17	1 245

Source: Statistics Cook Islands: Quarterly Statistical Bulletin, December 2007

HOUSEHOLD EXPENDITURE AND INCOME

A family income census[6] for Rarotonga in 1987 indicated that 41 percent of the 3 600 families surveyed had an annual income below $10 000 and only 1.4 percent had incomes exceeding $20 000.

6 The income census was undertaken by the Ministry of Planning and Economic Development, Cook Islands.

Remittances from Cook Islanders living overseas have for many years made a significant contribution to the economy; raising household expenditure and living standards beyond the level which could be otherwise be sustained. For some years, the remittances passing through the Post Office Bank in the form of money orders totaled around $2 million annually, with a peak of $2.64 million in 1987, the year of cyclone Sally. Gross Domestic Product per capita for the Cook Islands was estimated at NZ$13 158 in 2006.

THE AGRICULTURE SECTOR IN THE COOK ISLANDS

GENERAL

The limited land area and the remoteness of the islands place agricultural development in the Cook Islands at a great disadvantage compared to other PICs especially in terms of transportation, marketing and economies of scale.

The agriculture sector is characterized by a traditional land tenure system which can restrict full land utilization but encourages a high level of part-time activity in agriculture production; limited and expensive inter-island and international shipping and air transport services; limited labor supply; restricted availability of long-term credit; and a high level of government subsidy for agriculture.

Recognizing the transport limitations in the Cook Islands and the changing market demands, the Ministry of Agriculture has been actively promoting niche marketing strategies for high value, exotic fruits. This policy takes advantage of the climate and soil fertility of the Cook Islands and helps overcome the major problems of freight costs being too high a proportion of expected market returns to ensure continued economic viability of production.

The two island groups making up the Cook Islands portray marked differences in their agricultural activities. People in the Northern Group particularly in the islands of Manihiki and Penrhyn are becoming less involved in agriculture activities due to pearl farming which is a highly profitable venture for the islanders. Seaweed farming has been introduced in Pukapuka with high expectations of supplying export markets.

The Southern Group on the other hand continues to indulge in a much more diversified agricultural industry. This group has the benefit of a cooler climate

and more fertile soil enabling a wider variety of agricultural production. Regular air and sea transportation enhances export opportunities particularly to New Zealand. The main crops are banana in Aitutaki; taro in Atiu and Mangaia; and pawpaw, citrus, nono, taro and vegetables in Rarotonga. Cassava and taro are prominent in Atiu, Mauke and Mitiaro.

Agriculture is still the main activity in the Southern Islands with the exception of Rarotonga where trade, tourism and service-related sectors are the major sources of income.

For the country as a whole, agriculture and fisheries are the principle productive sectors of the economy, contributing an estimated 15.2 percent (at average 1990 prices) of the country's GDP in 2000.

There are three main export products from the Cook Islands with the nono (*Morianda citrifolia*) being the new trend and having expanded to being harvested from the outer island's naturally grown stock. It is noted though that many nono plantations on Rarotonga are being neglected as farmers lose interest or migrated overseas.

Generally export products from the agriculture sector have declined in the last ten years. Pawpaws in 2000 brought in $350 000 compared to a peak of $1.5 million in 1993. Maire (*Alyxia elliptica*) exports to Hawaii continue though production has dropped to less than $50 000 in 2000 compared to $200 000 in 1994. Approximately $20 million worth of fresh and processed foodstuff is imported into the Cook Islands annually; about 2 tons of fruit and vegetables are imported from New Zealand on a weekly basis[7].

CASH CROPS

The main export cash crops have been: copra; banana on Aitutaki; pineapples on Mangaia and Atiu; vegetables and root crops from Mauke and Rarotonga; and citrus, pawpaw and other fruits from Rarotonga. The pineapple industry is now defunct and copra, once the largest component of agriculture production, ceased production in the northern group in 1987 due mainly to depressed world

7 Cook Islands National Report. United Nations Convention to Combat Desertification.

market prices. Commercial production of coconut picked up in 1987 as copra production ceased when a coconut cream factory was established. Taro, cassava and breadfruit are also planted mainly for local consumption.

Banana exports from Aitutaki ceased due mainly to inconsistent quality, irregular shipping, and inability to compete with imports to New Zealand from other countries. Citrus production is continuing on Rarotonga for the local market but exports to New Zealand of both fresh fruit and juice could not compete with South American produce and exports. Although pawpaw production peaked in 1988 at 1000 tonnes and fell to 600 tonnes in 1990, interest in production remain high. The recent acquisition of a cool store provides an avenue for improving the quality and transport conditions for pawpaws and other perishable products. Beans, eggplants and chilli are also produced with favorable net returns to the farmers.

Although export of cash crops has declined markedly in recent years, indications are that there has been a significant rise in the value of fruit and vegetables sold at the local market. Such value was estimated by the Ministry of Agriculture (MOA) to be about $8 million in 1990. Because of the obstacles faced by cash crop exporters, MOA has been leading a shift away from bulk perishable crops to those with long storage life, ease of transport, favorable quarantine conditions and assured markets such as arabica coffee and vanilla. The former has been successfully developed on Atui while both have shown promise for Mauke, Atiu and Mangaia.

FISHERIES

Harvesting of fish resources within the Cook Islands' Exclusive Economic Zone (EEZ) has been very limited with only a small number of full-time commercial fishermen and about 40 part-time commercial fishermen, mainly on Rarotonga and Aitutaki to supply the local market. There are a number of bilateral fishing agreements and licenses for foreign fishing vessels have made a useful contribution to the country's foreign exchange earnings.

Shortage of fresh fish in Rarotonga is a common occurrence and the expansion of artisanal fishing activity must therefore remain a priority if tourists and locals expectations of fresh seafood are to be met.

The inshore marine systems of the atoll lagoons and reef-flat moats (lagoons) are reef-rim have been fished for generations. In recent times, fishing pressure has increased such that some species have been seriously impacted, such as Black-lipped Pearl Oyster on Swarrow and Manihiki, the Green Turtle on Palmerston, the giant clam on Aitutaki and the milkfish on Aitutaki. Trochus was first introduced on Aitutaki in 1957 and commercial harvesting commenced in 1980. Giant clams were recently introduced to improve the economy of Aitutaki and for replenishing the natural stocks. The Trochus Act of 1985 provides for the management of this resource.

PEARL INDUSTRY

The exploitation of pearl oyster shell was a major activity of the Northern Group but declined in the latter part of the 1960's due to declining stocks. The focus is now on the farming of pearl oyster for both cultured pearl and shell, particularly on Manihiki, Penryhn and Rakahanga where the lagoons are more suitable for producing cultured black pearls. Manihiki, the pioneer of the black pearl industry is home to the majority of operators (57 percent), followed by Penrhyn (36 percent) and Rakahanga (6 percent). The remaining 1 percent of operators resides on Rarotonga although their farms are on Manihiki.

The value of pearl shell more than doubled in the period 1985–1990 to about $13 per kilogram with total value of the industry reaching more than $500 000 in 1990 alone. Cultured pearl has proven to be a highly successful resource development for the Northern Group that a lucrative and expanding industry has since been established there. On Manihiki, there are more than 200 licensed pearl farms with about a 100 still active.

FORESTRY

The coastal lowland and low volcanic inland forest ecosystems of the Southern islands are highly disturbed by man-made activities. This process of transformation began with the horticultural activities of the first Polynesian settlers who arrived as early as about 2 400 years ago. The process accelerated after the arrival of the London Missionary Society missionaries in the 1820s, with the introduction of new food plants and the growth of commercial horticulture. At present, the rugged limestone makatea of the raised islands and the steep

upper-inland of Rarotonga are the only essentially natural terrestrial ecosystems that remain. The Northern atolls have had their coastal forests replaced by coconut plantations, with the exception of one area on Motu Kotawa on Pukapuka. Even the uninhabited islands of Suwarrow and Takutea have had their native forest impacted by the planting of coconut palms for copra. However, the continued absence of human population mean that these islands still support very significant mixed colonies of breeding seabirds and large coconut crabs. Both islands are protected: Takutea as a Wildlife Sanctuary since 1903, and Suwarrow as a National Parks since 1978.

The main groups of native plants found in the Cook Islands are flowering plants, ferns, mosses, lichens, fungi and algae. Only the flowering plants and ferns have been well researched in terms of endemicity and abundance.

Over the past thirty years there have been numerous proposals to create various protected areas to conserve particular species and/or ecosystems, such as the inland Cloud Forest of Rarotonga, and the Rarotonga fly-catcher. Since the declaration of the Suwarrow National Park in 1978, only one other terrestrial area – the Takitumu Conservation Area – was established under an agreement by the landowners to conserve the habitat of the Rarotonga fly-catcher (*kakerori*).

In recent years, concern has been expressed about the potential disappearance of the indigenous species of sandalwood (*Santalum insulare*) which is found only on the island of Mitiaro. As a hemi-parasite, sandalwood depends on other plants for some of its nutrient requirements, thus any slight disturbance on the surface soil that affect adjacent host plants will also affect sandalwood growth and survival.

Other species of sandalwood (*S. austral caledonicum*) have been introduced and have been found to also grow well especially on makatea islands such as Mangaia, Mitiaro, Atiu and Mauke. Reports[8] produced during the past 5–6 years have pointed to the need to persuade government entities on the islands to adopt or accept sandalwood planting as an alternative land-use activity. Mangaia has started a small 'enrichment' planting programme but there is a great need to get more local farmers to become involved.

8 J. Holcomb, 2002; Nooroa Tokari and Rainer Blank, 2004.

THE SIGNIFICANCE OF CLIMATE CHANGE TO THE PACIFIC ISLAND COUNTRIES

The significance of climate change to PICs is best described by the following paragraphs from 'Pacific at Risk: Our Knowledge, the Reality'[9].

SEA-LEVEL RISE

The 'best estimate' of global sea-level rise by the Intergovernmental Panel on Climate Change (IPCC) is an increase of about 50 cm by the year 2100.Current observational data for the Pacific indicate an average sea-level rise of 2–3 mm per year which falls within the same range of magnitude as that produced by the global scenario. It is not currently possible to state with certainty whether a clear long term trend exists, because detailed recording of sea level in the Pacific Ocean has only been carried out since 1991. However it is worth noting that based on data from the 11 tide gauges installed in 11 Pacific island countries, relative sea levels in the South Pacific have been rising by as much as 25 mm per year since 1994. This is more than 10 times the global rate of sea-level rise this century. This finding is validated by satellite data which show an increase of 2–3 cm per year particularly from Papua New Guinea to Fiji. The cause of this variation is not clear, but appears to be related to changes in ocean currents associated with El Niño events.

According to a SPREP-commissioned report from Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), human emissions of greenhouse gases up to 1995, and the consequent global warming mean a 5–12 cm sea-level rise is already inevitable. The oceans take some decades to fully absorb extra atmospheric warming, and the CSIRO estimates that this sea-level rise resulting from human emissions up to 1995 would peak in about 2020–2025. The CSIRO, using agreed IPCC scenarios, also studied likely future sea-level rise if

9 Produced by SPREP's Climate Change and Integrated Coastal Management Programme through the Pacific Islands Climate Change Assistance Programme (PICCAP), with funding assistance from the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP).

all countries met their Kyoto Protocol commitments, and if technology made it possible to cease all human emissions after 2020. This admittedly optimistic scenario would produce sea-level rise of 14–32 cm, peaking in about 2050. Such an increase, even without the associated increased height of storm surges coming off a higher sea level, is of deep concern to the small islands which are only one meter above mean sea level.

TROPICAL CYCLONES

A second CSIRO report, also commissioned by SPREP, shows that while there is no evidence that there might be a change in the number of tropical cyclones when CO_2 atmospheric concentrations have doubled, it is considered likely that climate change will lead to some increase (0–20 percent) in maximum tropical cyclone wind speeds and lower pressure. This increase in cyclone intensity raises concerns about damage from storm surges – the dome of water forced ahead of the storm by strong winds. Many small island nations are only one or two meters above sea level, and an increase in the height of storm surges would mean greater risk that waves driven by cyclonic winds could sweep entirely over many inhabited Pacific islands.

RECENT WEATHER CHANGES

Region-wide studies have shown recent significant changes in major weather patterns in the central and southern Pacific. The El Niño Southern Oscillation (ENSO) weather pattern has changed its behavior noticeably since 1976, with more El Niños, fewer La Niñas, the two biggest El Niños on record (1982–83 and 1997–98) and the longest El Niño on record. Statistically, these changes are unusual, and some researchers have speculated that they could be connected to global warming. These recent changes in El Niño patterns have significantly affected Pacific tuna catch volumes, resulting in substantial reductions in seasonal tuna catches for many PICs. El Niño was also responsible, in 1997–98, for severe droughts and water shortages in many PICs and for the extremely high sea-level rise of some 25 mm, recorded across much of the Pacific since 1994.

Another study by New Zealand's National Institute of Water and Atmospheric Research (NIWA), has pointed to a strong connection between El Niño events and the occurrence of tropical cyclones in the Pacific. For the South-West Pacific, the strong El Niño years of 1996–97 and 1997–98 had the highest frequencies of tropical cyclones on record, with a total of 32 tropical cyclones.

In another significant and substantial change in weather patterns, the South Pacific Convergence Zone (SPCZ) – a vast belt of storms and winds – abruptly shifted eastwards in 1977, changing patterns of rainfall and sunshine in every South Pacific island country. A NIWA-led study found that the northern Cook Islands, Tokelau and parts of French Polynesia have become substantially wetter since the late 1970s, while Fiji, Tonga, Vanuatu and New Caledonia have become drier. Central and western Kiribati, Tokelau and north-eastern French Polynesia became 0.3°C warmer between 1977 and 1994. Over the same period these countries became wetter and cloudier, with a 30 percent increase in rainfall compared with pre-1977 averages. For New Caledonia, Vanuatu, Fiji, Tonga, Samoa and the southern Cook Islands, average rainfall decreased by 15 percent after 1977.

PACIFIC TEMPERATURE INCREASES

A joint New Zealand-Australian analysis of Pacific island weather records has revealed that since 1920 the surface air temperature rose by 0.6–0.7°C in Noumea (New Caledonia) and Rarotonga (Cook Islands). This is greater than the mean global increase. Based on data from 34 stations in the Pacific Ocean region, from about 160° E and mostly south of the equator, surface air temperatures have increased by 0.3–0.8°C this century, with the greatest increase in the zone south-west of the SPCZ. This is also well in excess of global rates of warming. A joint NIWA/Hadley Center study has corroborated the warming in the Pacific, confirming similar increases in surface ocean temperatures throughout the South Pacific.

OBSERVED RECENT CHANGES

Until recently, scientific research in the region has been sparsely scattered, making it difficult to definitively establish long term trends. However, the inhabitants of many Pacific island atoll and island insist that what they are observing today is in many cases very different from what they knew one or more decades ago.

These disruptive changes are consistent with many of the anticipated impacts of global climate change. They include extensive coastal erosion, persistent alteration of regional weather patterns and decreased productivity in fisheries and agriculture. Higher sea levels are making some soils too saline for cultivation of crops such as taro, pulaka and yams. Coastal roads, bridges, foreshores and plantations are suffering increased erosion, even on islands that have not experienced inappropriate coastal development.

Recent devastating droughts have hit export crops and caused serious water shortages in many Pacific island countries, including the Federated States of Micronesia, Fiji, Marshall Islands, Papua New Guinea, Samoa and Tonga.

There are increasing reports indicating the more widespread and frequent occurrence of mosquito-borne diseases such as malaria. Malaria is even being reported in highlands of Papua New Guinea and the Solomon Islands where previously it was too cold for mosquito to survive.

It is too early to say if these observed changes are the beginning of a long-term climate change rather than further manifestations of the natural variability of climate that characterizes the Pacific islands region. However, they are the sorts of changes which can be expected as global warming sparks climate change.

Climate change, once started, continues to intensify for decades if not centuries. If the observed changes noted above are indeed precursors of global climate change impacts, then the Pacific's many small island countries and territories face serious, wide-reaching and long-term consequences of human emissions of greenhouse gases.

CLIMATE CHANGE SCENARIO IN THE COOK ISLANDS

The South Pacific Convergence Zone (SPCZ) and its movement between the Northern and Southern groups is an important phenomena for influencing the weather patterns of the Cook Islands. The SPCZ varies from month to month, and the weather in the Southern group is largely dependent on its position and intensity.

The SPCZ usually lies in the Southern Group during the months of November to April, bringing high humidity and heavy rains. At this time, the Northern

Group experience dry, hot weather. From May to October, the SPCZ and the unsettled rainy weather move to the Northern Group while the Southern Group experiences a dry season.

TABLE 3: **AVERAGE TEMPERATURE AND TOTAL RAINFALL FOR RAROTONGA, AITUTAKI AND PENRHYN**

PERIOD	AVERAGE TEMPERATURES (CELSIUS)			TOTAL RAINFALL (mm)		
	Rarotonga	Aitutaki	Penrhyn	Rarotonga	Aitutaki	Penrhyn
2003	24.6	25.9	29.2	2 073	952	1 862
2004	24.8	26.1	28.8	1 724	602	1 994
2005	24.6	25.5	29.0	1 969	793	1 179
2006	24.8	25.5	29.1	2 246	1 460	1 882
2007	25.0	25.3	29.0	1 991	1 828	2 024

The Cook Islands average about three cyclones in every two years but there are also cyclone-free seasons. The formation of tropical cyclones during the wet season is a major climatic feature of the Southern Group; they seldom affect the Northern Group.

Between 1940 and 1997, 13 tropical cyclones were reported in the Cook Islands but only four resulted in damage to the atolls. Cyclone "Martin" in 1997 however affected Manihiki causing the death of 11 people. Tropical cyclone "Pam" also occurred during ENSO and although the damage was minimal, 213 mm of rain fell in a time span of six hours on Rarotonga, breaking a long period of drought. The rest of the southern group of islands experienced pronounced drought periods during the same time.

El Niño and La Niña are also significant weather events for the Cook Islands. El Niño spells were recorded in 1982/83, 1986/87, 1991/1995 and 1997/98 dry seasons.

During El Niño episodes, the Southern Group experience a reduction in rainfall by up to 60 percent of the annual rainfall of 2 000 mm while in the Northern Group, the annual rainfall of 2 300 mm increases by up to 200 percent. This situation is reversed during the La Niña episode whereby the Northern Group

would have a reduction in the normal rainfall while the Southern Group would have an increase in their normal annual rainfall.

Scenarios of possible future climate and sea levels in the Cook Islands and the Pacific islands' region are not available. However, based on the projections developed by the IPCC and the simulated results from two General Circulation Models (GCMs), the temperature and rainfall scenario for the Cook Islands up to 2100 could be developed, as shown in Table 4.

TABLE 4: **TEMPERATURE AND RAINFALL SCENARIO FOR THE COOK ISLANDS**

GCM PATTERN	2020		2050		2100	
	Temp. (C)	Rainfall (%)	Temp. (C)	Rainfall (%)	Temp. (C)	Rainfall (%)
HADCM	0.6	5.1	1.2	10.3	2.2	18.9
CSIRO9M	0.4	-0.1	0.8	-0.1	1.5	-0.2

Source: Cook Islands Initial National Communication, UNFCCC

The above Table shows temperature scenarios using two different GCMs, one by HADCM (UK) and the CSIRO9M (Australia). While the magnitudes of the various model scenarios differ, they indicate that, over the next century, there could be an increase in temperature of between 0.4°C and 2.2°C over those presently experienced. It should be noted that while the projected temperature increases, especially those from the middle range scenario, do not seem particularly large, they would be superimposed on what is already a hot climate, thus any slight increase in temperature becomes significant.

At present many GCMs are not yet able to reliably indicate how rainfall patterns might change in the region as shown by the two GCM results above. One output shows that wetter conditions will prevail (HADCM), while the other indicates there may be drier conditions in the future. Some climate scientists have indicated the possibility that rainfall might be characterized by high intensity events on the one hand, and prolonged droughts n the other. Other work indicates that such extremes in the Pacific region may also be dominated by the ENSO phenomenon.

The only scenarios of sea-level change for the Cook Islands, drawn from the current global projections based on the IPCC Second Assessment Report

and are presented in Table 5, for a best guess and high estimate of greenhouse gas emissions. Both show significant increases in global sea level over the next century. However, it can not be assumed that changes in sea level at regional and local levels will necessarily be the same as the global average change because of the influence of relative sea level associated with vertical land movement, which affects sea level. Dynamic effects resulting from oceanic circulation, density, wind and pressure patterns, and ocean currents also influence sea level at the local and regional level.

TABLE 5: **SEA-LEVEL RISE SCENARIOS**

SCENARIOS	2020	2050	2100
1S92a (best guess)	8 cm	20 cm	49 cm
1S92e (high)	16 cm	40 cm	94 cm

Source: Cook Islands Initial National Communication, UNFCCC

Table 5 provides a broad indication of what might be expected over the next century, based on middle and worst emissions scenarios of sea level change. These projects are consistent with the temperature projections suggesting that there will be substantial increases in temperature both temperature and sea levels for the Cook Islands in the next century.

LIKELY IMPACTS OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY

Cook Islands agriculture, by its very nature, is relatively vulnerable to changes in normal weather conditions, wet or dry seasons including unusual weather patterns over time as a result of global warming.

The Cook Islands, like other Pacific Island Countries are already experiencing the adverse effects of climate variability and extremes and they remain extremely vulnerable to future changes and greater risks. Cook Islanders have relatively high per capita income and therefore the country does not suffer from food insecurity. In addition, almost all Cook Islanders have access to some land and

to the lagoons and ocean where they have always grown and caught their own subsistence food. Natural calamities such as drought and cyclones occasionally disrupt food production but have not yet posed a major threat to food security in the country.

Commercial agriculture in the Cook Islands has and continues to suffer the effects of droughts. Rainfall in 1997 was 32 percent below the 1971–97 average and for the first three months of 1998, rainfall was 10 percent below that in the corresponding period in 1997. As a result pawpaw volumes and export sales were lower in 1997. Farmers and other people interviewed during this study agreed that mangoes and breadfruits are fruiting much earlier than normal with some saying there now appears to be two seasons for these fruit crops instead of just one as was the case in the past. Many attribute this phenomenon to change in climatic conditions particularly reduced rainfall.

Increased temperature is believed to be largely responsible for the prolific increase in population of insects such as mosquitoes which are said to be affecting, even killing domestic pigs on one island in the Northern Group. On Mangaia, Aitutaki, Pukapuka and Mauke, taro growth has been seriously constrained due to lands becoming drier. There are also reports of coconut dieback due to insect infestation, mango fruits falling prematurely, banana trees not bearing fruits, jackfruits rotting before ripe, and custard apples not fruiting for the last three years. On Aitutaki, lands are reported to be drier and vegetables there do not look as healthy as on Rarotonga.

Farmers on Rarotonga pointed out that there has been so much rain so far this year that irrigation has not been required. However, probably as a result of wetter conditions, some new insect pests have been discovered on taro leaves. The potato white fly which is not a major pest in New Zealand has become a major concern for the Cook Islands (Mataio Reti, *Pers. Com.*). Population of yellow wasps is believed to have increased significantly on Pukapuka following the 2005 cyclone (Carruthers, *Pers. Com.*).

Storm surges and rising sea levels also affect agriculture in the Cook Islands. During a cyclone in 2005, entire taro plantation areas on Pukapuka were completely inundated by salt water. It took 3 years before taro could again be reintroduced to the island (Mataio, Carruthers, *Pers. Com.*). Salt spray which is a major threat

to agriculture in the outer islands is not such a big problem on Rarotonga where gardens are normally established on higher grounds.

Sea-level rise, salt spray and sea water intrusion have impacted on agricultural activities especially on the low-lying atolls of the Northern Group. They impede crop growth and further reduce the amount of land available for crop production. Lack of rain likewise reduces agriculture production. As experienced during cyclone "Martin", cyclone-induced strong winds and wave surges can also cause considerable damage to agriculture farms and crops.

Higher volcanic islands of the Southern Group have also experienced problems as a result of climate change. Excessive rain has resulted in the loss of some once productive agriculture lands and the flooding of plantation areas. These areas when dried after the cyclones often become boggy and difficult to cultivate.

While it is still unclear how climate change will affect fisheries and marine resources, it is believed that the long term effects of climate change including its impact on ocean circulation and sea levels will threaten fisheries and marine resources in the Cook Islands. As sea temperatures already frequently exceed the temperature tolerance level of coral species (25–29°C), it is likely that any significant increase in sea temperature in the future will result in more frequent and severe episodes of coral death and coral bleaching, thus reducing productivity of the marine areas.

Changes in the concentration and availability of fish stocks are also likely to occur should average sea temperatures continue to change in future. The recent ENSO event saw a major shift in offshore fish distribution patterns as tuna fish stocks migrated according to oceanographic surface temperatures and salinity fronts. Further global warming and circulation of the ocean would no doubt have a major effect on the distribution of the tuna fishery resources of the Cook Islands' 200-mile EEZ.

The pearl industry, the second most important economic sector for the Cook Islands also face considerable risk from cyclone damage. Cyclone "Martin" in 1997 caused damage to about 95 percent of the farmers' land-based infrastructure and to 15 percent of the cultured pearl shell. Pollution from land-based activities and from cyclone-induced flooding has resulted in poor water quality thus affecting the health and growth of cultured pearls. Elevated water temperature conditions are conducive for disease outbreaks and coral bleaching.

Increased temperatures, prolonged dry periods and high winds also cause heat stress thus affecting forest tree growth. This ultimately affects nesting-grounds for land and seabirds as well as facilitates the spreading of wind-dispersing weeds such as the balloon vine and other invasive species.

Domestic water sourced from stream catchment is limited in the Cook Islands. There is therefore a high dependence on rainfall which means the country is highly vulnerable to changing weather patterns and during times of drought. Periods of heavy rainfall too can cause problems to the water supply. Heavy downpour often causes flooding in the inland streams washing debris downstream and causing sedimentation of lagoons. This affects the health and productivity of the lagoons and reefs.

TYPOLOGY OF CLIMATE CHANGE IMPACTS

The likely impacts of climate change and climate variability on agriculture and food security in the Cook Islands and potential response options are summarized in Table 6.

TABLE 6: **IMPACTS OF CLIMATE CHANGE AND POTENTIAL RESPONSE OPTIONS**

THREAT	IMPACT	POTENTIAL RESPONSE
Increased temperatures / low rainfall / droughts	~ Plants / trees growth stress ~ Wilting and scorching of plants and fruits ~ Low productivity due to slow growth ~ Reduced availability and supply of ground water for agriculture irrigation ~ May result in prolonged dry spells increasing salinity of soils for agriculture purposes ~ Increase insect populations affecting domestic livestock ~ Could cause coral bleaching ~ Affect fish catches ~ Low productivity of farmers due to heat stress ~ Affect planting and harvesting regimes	~ Introduce heat tolerant crop varieties ~ Improve capacity of rainwater catchment for irrigation ~ Monitor use of groundwater during dry periods ~ Encourage crop rotation and fallows to maintain soil fertility and productivity ~ Move gardens to upland areas ~ Apply insect/pest management control measures ~ Monitor and document impacts of climate change on marine environment and resources ~ Manage working hours and adjust planting and harvesting regimes according to changes in weather patterns

[→]

[—>] Table 6 continued

THREAT	IMPACT	POTENTIAL RESPONSE
Increased rainfall and flooding	~ Increased ground water supply thus alleviating water shortage problem ~ Flooding of agriculture lands ~ Erosion of productive coastal lands ~ Rotting of vegetables ~ Create favorable conditions for increase of pest and fungal diseases affecting agriculture crops and trees ~ Contamination of groundwater lenses ~ Pollution of coastal waters affecting growth of pearl industry ~ Improve conditions for water borne diseases that could affect health and hence productivity of farmers	~ Improve rainwater storage facilities to keep excess water ~ Improve water drainage within agriculture lands ~ Apply coastal management and protection techniques ~ Restrict use of groundwater during wet season ~ Plan to harvest prior to commencement of wet season to avoid wastage due to rot and fungal diseases ~ Plant trees and stabilize lands that are vulnerable to erosion ~ Carry out research into other varieties and species that are more tolerant to different types of conditions that are present in the Cook Islands
Cyclones and strong winds	~ Damage to agriculture crops ~ Loss of agriculture production and income ~ Destruction of agriculture infrastructure and storage facilities ~ High cost of rehabilitation ~ Spread of wind borne diseases and pests ~ Create opportunities for invasion by alien plant and insect species	~ Carry out salvage harvests where appropriate ~ Consider local processing of cyclone-damaged fruits and crops to other by-products for domestic use ~ Prepare and implement cyclone emergency management and investment plans ~ Apply pest management and control measures
Wave surges, rising sea levels and salt spray	~ Damage to agriculture crops and lands from salt water intrusion, salt spray and flooding ~ Erosion of coastal lands ~ Contamination of groundwater lenses ~ Pollution of coastal areas due to erosion and sedimentation ~ Loss of productivity as plants and gardens are affected by salt water ~ Loss of traditional food crops as their habitats become too exposed to rising sea levels	~ Move agriculture lands away from low lying areas ~ Apply coastal protection infrastructure and control measures ~ Plant coastal tree species to protect coastal areas vulnerable to rising sea levels and wave surges ~ Plant trees as "buffers" for cash crops and fruit trees ~ Improve genetic research on traditional food crops and fruit trees ~ Identify and document impacts of rising sea levels on cash crops

OTHER FACTORS CONTRIBUTING TO THE VULNERABILITY OF THE AGRICULTURE SECTOR

Initially, the Cook Islands economy was dominated by the primary sector and focusing on agriculture and fisheries. However, the agriculture sector has been struggling over the past decade to regain its position as a key economic driver. In addition to problems associated with climate change and climate variability, a number of other factors also contribute to the vulnerability of the agriculture sector in the Cook Islands. These are described below.

HIGH POPULATION CONCENTRATION ON RAROTONGA

The high concentration of the population on Rarotonga is already putting considerable pressure on that island's limited land resources as more and more lands are being converted for settlement and for tourism infrastructure development. Such high population concentrations have led to environmental problems (high water usage resulting in the pollution of water lenses, slow replenishment of water lenses, waste disposal, vegetation clearing) which in turn make the islands more vulnerable to natural hazards. The problem is exacerbated by the increasing number of tourists most of whom spend time on Rarotonga. Expanding economic activities in the outer islands might encourage people to return to their home islands but this is unlikely to happen any time soon. Whatever decision is taken, it is quite clear that the population density in Rarotonga is unsustainable and there is therefore an urgent need to address this problem as a matter of high priority.

LOW PRIORITY ACCORDED TO AGRICULTURE DEVELOPMENT

Although early development policies favored a movement towards self-sufficiency in the agriculture sector, considerable constraints to expansion of the sector still exist and as long as these constraints remain, government priority has and will be redirected elsewhere. Land shortage, high labor costs, minimal taxation on imported goods, limited marketing infrastructure, inadequate and expensive transportation systems frustrate developments in the sector and will in turn, cause government to invest in other more worthwhile development activities.

The 2007–2010 National Sustainable Development Plan projects that "the government will continue to concentrate on developing niche markets for viable crops and commodities for domestic use, import substitution, and/or export, as well as strengthen biosecurity policies and control structures". The development of such market will be crucial to reinvigorating the agriculture sector in the Cook Islands.

CHANGING PATTERNS OF FOOD CONSUMPTION

In recent years, diets have been slowly but steadily transformed away from one based on local foods (breadfruit, taro, banana) to one in which imported food is preferred; even in the outer islands where imported foods are now an important component of peoples' diet. In many places, the fatty imported chicken is preferred over the locally-raised chickens. The same is true of other imported food stuff like rice, flour, tinned and frozen meat which are often cheaper than local produce but of less nutritional value. These changes in food consumption, coupled with the limited and impoverished lands for agriculture make it very difficult for government to encourage and promote further development in this sector. This is amply demonstrated in the loss of the agriculture research station and the abolishment of the forestry division of government.

LACK OF MARKET OUTLETS, STORAGE FACILITIES AND HIGH COST OF TRAVEL TO OUTER ISLANDS

The lack of market outlets where farmers can sell their products on the outer islands mean there is no incentive for islanders to produce more than they need for domestic consumption. To compound the problem, when fishermen are able to catch more than they needed as they often do, there are no proper cooling facilities available on the islands to enable them to store their catches until they are able to arrange transport and sale in Rarotonga. As if this is not enough, the cost of travel between Rarotonga and some of the islands in the Northern Group is so high that it is often beyond the ability of the farmers and fishermen to afford. The continuing rise in the price of fuel has in fact put so many commercial fishermen out of business.

CLIMATE CHANGE RELATED ACTIVITIES OF OTHER ORGANIZATIONS IN THE COOK ISLANDS

The Cook Islands participated in the Pacific Islands Climate Change Assistance Programme (PICCAP), a regional project managed by SPREP. The PICCAP marked the start of climate change information dissemination activities in the country initiated by the creation of a multi-disciplinary group as part of the Climate Change Country Team. Activities carried out under the project included the implementation of national vulnerability assessments and national greenhouse gas inventory as well as the drafting of the First National Report to the UNFCCC. The project ended in 2002 but follow-on efforts continued to add-on activities such as the two-year Adaptation project for Aitutaki and the Capacity Development Initiative (CDI).

The Cook Islands was included in SOPAC's comprehensive hazard and risk management (CHARM) initiative which provided a consistent approach to risk management across the Pacific region. The approach recognizes the isolation factor of the outer islands and the transportation limitations which highlights the small island's vulnerability to disaster risks. The CHARM approach to disaster management shifts the focus from recovery and response to preparedness and risk reduction.

ADB's Climate Change Adaptation Programme for the Pacific (CLIMAP) assists Pacific developing member countries to enhance their adaptive capacities and resilience to climate change and climate variability, including extreme events. It also assists these countries to prevent and address the adverse effects of global climate change, particularly sea-level rise and changing climate variability in coastal areas. CLIMAP builds on ongoing and recently completed adaptation programs through a consultation and analysis process and follows an integrated approach covering economic, financial, technical, and legal aspects as well as social, environmental and networking dimensions.

In 2005, the ADB commissioned a case study in the Cook Islands and FSM on Climate Proofing, A Risk-based Approach to Adaptation. The case study is the result of a regional technical assistance (RETA) funded under REACH by the Canadian Cooperation Fund for Climate Change – Greenhouse Gas Abatement, Carbon Sequestration and Adaptation.

PACIFIC ADAPTATION TO CLIMATE CHANGE PROJECT (PACC)

The PACC is a regional project implemented by SPREP involving 13 PICs. The main objective of the project is to build PIC capacity to adapt to climate change. In the Marshall Islands, the PACC is focusing on ways to reduce pressure on the water supply system including more effective irrigation systems (example, bucket irrigation) and increasing capacity of rainwater catchment facilities in order to reduce dependency and pressure on ground water sources. The SPC, SOPAC and JICA have all shown interest in improving the water supply situation in the RMI.

SOUTH PACIFIC SEA LEVEL AND CLIMATE MONITORING PROJECT (SPSLCMP)

With funding from AusAID, the SPSLCMP has from 1992, installed a number of SEAFRAME stations on several Pacific island countries including the Cook Islands to provide accurate and long term sea level records. The SEAFRAME gauges record sea level, air and water temperature, atmospheric pressure, wind speed and direction. The SPSLCMP was a response to concerns raised by the FORUM leaders over the potential impacts of an enhanced greenhouse effect on climate and sea levels in the Pacific region.

PACIFIC ISLANDS RENEWABLE ENERGY PROJECT (PIREP)

The Cook Islands, together with a number of other Pacific island countries took part in the Pacific Islands Renewable Energy Project (PIREP) which started in 2003. This project was carried out over a period of 18 months and had as its main goal the removal of barriers to the development and commercialization of renewable energy in the PICs that influence country efforts to reduce the long term growth of greenhouse gas emissions from fossil fuel uses, especially diesel. Following the completion of the PIREP, another project, the Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) with a similar objective to the PIREP was started. Cook Islands is also participating in this project.

PACIFIC ISLANDS FRAMEWORK FOR ACTION ON CLIMATE CHANGE (PIFACC)

In 2005, the Pacific Leaders adopted the Pacific Islands Framework for Action on Climate Change 2006–2015 with a goal to ensure that Pacific island people build their capacity to be resilient to the risks and impacts of climate change.

The Framework has the following objectives: i) implementing adaptation measures; ii) governance and decision-making; iii) improving our understanding of climate change; iv) education, training and awareness; v) contributing to global greenhouse gas reduction; and vi) partnerships and cooperation. Implementation of the Framework is further elaborated in the Pacific Islands Action Plan on Climate Change 2006–2015.

CAPACITY BUILDING TO ENABLE ADAPTATION MEASURES IN PACIFIC ISLAND COUNTRIES (CBAMPIC)

The CIDA funded SPREP executed Capacity Building to Enable Adaptation Measures in Pacific Countries project that commenced regionally in 2002 with pilot projects in the Cook Islands, Fiji, Samoa, and Vanuatu, had the broad aim of increasing the ability of Pacific Island people to cope with climate change. The Cook Islands' pilot site Aitutaki was selected based on its unique almost atoll geography, previous vulnerability assessments, and community interest.

COMMUNITY VULNERABILITY AND ADAPTATION ASSESSMENT (CV&A)

Using a participatory approach termed Community Vulnerability and Adaptation Assessment and Action, in a series of village based workshops the people of Aitutaki were asked by local trained facilitators to identify their general problems, prioritise these, and then focusing on climate related issues identify and prioritise solutions to those problems. This process consistently identified salty poor quality and insufficient drinking water as a priority problem, with household and community rainwater tanks and improvements to the main supply system as locally appropriate solutions.

ADAPTATION PROGRAMME FOR THE PACIFIC (CLIMAP)

ADB's Adaptation Programme for the Pacific assists Pacific Developing Countries to enhance their adaptive capacity and resilience to climate change and climate variability, including in extreme events. It also assist these countries to prevent and address the adverse effects of global climate change particularly sea-level rise and changing climate variability. This is achieved through risk assessment, adaptation planning and policy development and by "climate proofing" infrastructures, community and other development initiatives. This assistance involves preparation/design of adaptive measures at the project level as well as capacity building, including institutional strengthening and human resource development for adaptation. The Cook Islands and the FSM were included in a case study designed to assist Pacific member countries of ADB to adapt to current and future climate change risks through the use of the Climate Change Adaptation through an Integrated Risk Reduction (CCAIRR) framework and methodology to demonstrate a risk-based approach to adaptation, and to mainstreaming adaptation.

INITIAL NATIONAL COMMUNICATIONS TO THE UNFCCC

As a party to the UNFCCC, the Cook Islands like other signatories to the Convention has an obligation to prepare and submit an Initial National Communications (INC) report to the Convention Secretariat. The INC was funded by the GEF through the PICCAP executed by the SPREP. In addition to field studies and compilation of information, a national inventory of sources and sinks of GHG was also undertaken during the preparation of the report. Also included was an assessment of the country's vulnerability to climate change and sea-level rise with the help of the International Global Change Institute (Waikato, New Zealand) and the University of the South Pacific (USP) in Fiji.

EXISTING INSTITUTIONAL MECHANISMS AND POLICIES

KEY NATIONAL POLICIES

The key planning document for the Cook Islands is the National Sustainable Development Plan (Te Kaveinga Nui) 2007–2010 which sets out a 15-year visionary framework called "Living the Cook Islands Vision – A 2020 Challenge".

The NSDP reaffirms Cook Islands' commitment to its international and regional partners through the World Summit on Sustainable Development (WSSD), Mauritius Declaration, the Millennium Development Goals (MDGs), CEDAW, other Multilateral Environmental Agreements (MEAs), and the Pacific Plan to name a few. The NSDP has five strategic outcomes and eight strategic goals, as shown in Table 7.

The National Environment Strategic Action Framework 2005–2009 (NESAF) provides guidance and direction for achieving sustainable social and economic progress for the Cook Islands utilizing its natural resources and environment wisely. The third goal of the NESAF is to increase resilience by strengthening national capacities for climate change, variability, adaptation and mitigation.

TABLE 7: **STRATEGIC OUTCOMES AND GOALS OF THE NATIONAL SUSTAINABLE DEVELOPMENT PLAN**

STRATEGIC OUTCOMES	STRATEGIC GOALS
1 Well educated, healthy and productive people and resilient communities	1 Equal opportunities for education, health and other social services towards maintaining an inclusive, vibrant, resilient and productive society in harmony with our culture **(Outcomes 1 and 5)**
2 A secure society built on law and order, and good governance	2 A society built on law and order and good governance at all levels **(Outcomes 2 and 3)**
3 Sustainable economic growth in harmony with our social values, culture and environment	3 Innovative and well-managed private sector-led economy **(Outcomes 1 and 3)**
4 Responsible and mature foreign relations with New Zealand and other regional and international communities in the interest of the people of the Cook Islands	4 Sustainable use and management of our environment and natural resources **(Outcomes 1 and 5)**
5 Enhanced cultural and environmental values	5 A strong infrastructure base to support national development **(Outcomes 1 and 3)**
	6 A safe, secure and resilient community **(Outcomes 1, 2, 3 and 5)**
	7 A foreign affairs policy that meets the needs and aspirations of the Cook Islands people **(Outcomes 1, 2, 3, 4 and 5)**
	8 Strengthened national coordination and institutional support systems for development planning, evaluation and monitoring **(Outcomes 1, 2, 3, 4 and 5)**

The NESAF is intricately linked to the National Sustainable Development Plan (NSDP) which represents both the national strategies on Millennium Development Goals (MDGs) and National Sustainable Development Strategy. The NESAF replaces the National Environment Management Strategy (NEMS) as the Cook Island's leading environment policy framework for the next five years.

MAIN INSTITUTIONS

- The Ministry of Agriculture is the principal agency of government responsible for promoting the agriculture sector in the Cook Islands. The Ministry has been carrying out investigations into the performance of new high yielding cultivars of vegetables, root crops, and fruit trees with better production per unit area capacity under current climatic and soil conditions. Cultivars of vegetables and root crops with increased tolerance of droughts and water-logged conditions have also been investigated as so were those with pest and disease resistance traits. Species of taro that may have some tolerance of brackish water as found in the Northern Group islands are being investigated. Unfortunately, the Ministry had to give up its research station following a demand by the landowner for the return of family land on which the station was located.
- The National Environment Service (NES) or Tu'anga Taporoporo has responsibility for the administration of the 2003 Environment Act and has been directly responsible for the implementation of a number of environmental projects, including climate change projects, in the Cook Islands. The NES is the main agency dealing with regional and international treaties on the environment to which the Cook Islands is a party such as the CBD, UNFCCC and Kyoto Protocol, and the UNCCD and is the main point of contact for the region's environment organization, the SPREP. NES coordinates the work of working groups that carried out community vulnerability studies on Mangaia, Aitutaki, Penhryn and Mauke and is overseeing the preparation of the 2nd National Communications to the UNFCCC.
- The Ministry of Marine Resources is responsible for marine resource issues in the Cook Islands. It has several research arrangements with international organizations like the Flinders University of South Australia and University of Hawaii which maintain an array of tide monitoring gauges in the Cook

Islands. Coral coring surveys have been conducted for climate change with assistance from the University of Hawaii and TOGA Station University in Edinburgh. SOPAC offers assistance with coastal modeling as well as water resource investigations. The Ministry is providing assistance to communities to meet their subsistence needs for food security and has undertaken joint environment awareness initiatives with the NES.

- Preparedness and a "no regrets" approach to climate change have been implemented in the Cook Islands through the Emergency Management Cook Islands (EMCI) formerly known as the National Disaster Management Agency (NDMA). A national plan for Disaster Preparedness has been developed to ensure correct responses to the potential influence of climate change phenomena. The plan has identified information gaps that may threaten its effective implementation as lack of information on areas vulnerable to flooding, lack of information on drainage systems, and the need for legislation development. EMCI activates the National Emergency Operating Center (NEOC) during a disaster and has conducted emergency mock exercises to test the effectiveness or otherwise of response systems in place.
- The Cook Islands Meteorological Unit is the prime source for the most recent climatic data on the Cook Islands. It has six automatic weather stations (AWS) located on the islands of Aitutaki, Manihiki, Mangaia, Mauke, Pukapuka and Penrhyn. Synoptic three hourly weather reports are interrogated from a platform on each of these islands through a modem in the main office in Rarotonga. In addition, there are two air stations situated in Rarotonga and in Penrhyn. Data collected from these stations and from the SEAFRAME station will contribute to the global models that are implemented by the IPCC and other research organizations as well meet the needs of the Cook Islands community.
- The Cook Islands Association of Non-Governmental Organizations (CIANGO) is the umbrella organization for NGOs in the country. It has 58 financial members and 14 associate members and has carried out agriculture projects with FAO, EU and SPC assistance. CIANGO members also carry out projects in the outer islands and are often better placed to implement community-based projects that are sometimes difficult for government agencies to implement. CIANGO is the

focal point for the GEF Small Grants Programme (SGP) in the Cook Islands and often help communities prepare their proposals to the fund.

- The Cook Islands Red Cross (CIRC) is carrying out a "Preparedness for Climate Change Programme" which includes the creation of a plan of activities to prepare for and reduce risks of climate change to be implemented in the Cook Islands. The outer islands will be the priority focus of the plan. As past of this preparedness plan, the CIRC is preparing a video to document traditional methods of food preservation which could help people store food during times of disasters and extreme climatic events. CIRC is looking at building its responses to climate change by strengthening its partnerships with the NES, the DMA and NGOs active in climate change and will continue to influence policies where possible and share best practices with interested partners as needed.
- The Pacific Islands Framework for Action on Climate Change 2006–2015 builds on the Pacific Islands Framework for Action on Climate Change, Climate Variability and Sea-Level Rise 2000–2004 and aims to identify broad climate change priorities for the PICs. It is consistent with the timeframes of the Millennium Declaration, the Johannesburg Plan of Implementation and the subsequent work of the UN Commission on Sustainable Development.
- In addition to national policies and strategies, the Cook Islands, like other PICs, also participate and contribute to national initiatives that help to promote links with, but in no way supersede national instruments and plans across specific sectors that are linked to weather and climate including agriculture, energy, forestry and land use, health, coastal zone management, marine ecosystems, ocean management, tourism and transport.

NATIONAL STRATEGY TO MITIGATE AND ADAPT TO CLIMATE CHANGE

MITIGATION

Mitigation refers to the measures that will reduce the national release of GHGs. The Cook Islands is a very minor producer of GHG emissions both in terms of total emissions and emissions per head of population. Mitigation measures will enable the Cook Islands to further minimize any increase in its GHG emissions, however due

to existing needs for social and economic development, a reduction in releases would appear to be a lower priority for the Cook Islands government.

Most mitigation measures either reduce peoples' demand for GHG emitting products or else control their supply. They can incorporate education and awareness raising initiatives, fiscal measures such as financial incentives, taxes and charges, legislation to prohibit certain activities and policy measures. Some mitigation options believed to be of relevance to the current situation in the Cook Islands are discussed below.

- Decrease dependency on fossil fuel. Diesel generators provide the majority of electricity in the Cook Islands. The Cook Islands however has the potential to use a range of other alternatives for generation of electricity such as solar and wind. Solar energy is being used but in a very small scale. The demand by communities in outer islands for similar lifestyles as those living in Rarotonga would limit the use of this option especially in the outer islands where there is a greater and growing need for electricity.
- Decentralize services and economic activities. Increased decentralization of services and economic activities coupled with greater development of the local markets would do much to reduce current dependence on inter-island transport between Rarotonga and the outer islands. Such change would be facilitated by economic incentives for skilled workers and entrepreneurs to establish themselves locally rather than moving to Rarotonga. Several small farmers are in the outer islands and will benefit from not having to go far to sell their produce hence, there will be gains from reduced-emissions from inter-island travel.
- Enhancing the enabling environment for better environmental management. There is a need to recognize in the budgeting process the need to strengthen programme outputs and performance standards to provide greater focus on core environmental and resource management functions. Ensuring that legislation and regulations are not providing perverse incentives that result in environmental degradation but are encouraging decision making and actions that result in good environmental outcomes is an important challenge. Increasing the use of information management systems to improve the quality and environmental outcomes of decision making as well as compliance and enforcement including open access to information and sharing data bases and other information resources can go a long way in understanding and supporting actions to mitigate against climate change.

ADAPTATION

Adaptation refers to changes in technology, practices and policies that can prepare a country for the impacts of climate change resulting from GHG emissions. While the Cook Islands vulnerability to climate change and sea-level rise will be determined by the decisions and actions that are made today with respect to the management of the country's resources and the nature of its social and economic development, the Cook Islands is nevertheless in a position to adopt pro-active adaptation strategies that can be implemented immediately and sustained over the years to effectively reduce its vulnerability. However, there are three main obstacles to be considered:

- in the present socio-economic climate, it has been difficult to identify national resources that could be redirected to climate change adaptation activities from immediately pressing social development needs;
- climate change issues are, in general, poorly understood; and
- despite efforts to make climate change planning multi-sectoral, it has not been incorporated into the mainstream planning activities of many government agencies and sectoral organizations.

Given the poor state of knowledge and understanding of climate change issues that exist today, coupled with the limited financial resources and low levels of technology, the Cook Islands like many other PICs faces a formidable challenge to adapt to climate change. Some adaptation opportunities considered to be appropriate and achievable in the Cook Islands are discussed below.

- Improve research and understanding of subsistence root crops. The productivity, growth requirements and pathogens of the Cook Islands main subsistence crops are not well understood. Application of new technical know-how and skills to improve soil conditions, crop yields, animal husbandry and management, and improvement of agricultural facilities will help refocus attention on local resources and support current efforts to revive interest in these crops as substitutes for imported foods. Re-establishment of the research station on Mauke as planned will be critical to the achievement of this goal.
- Improve land use and physical planning mechanisms. Land use and physical planning that take into consideration the possible impacts of climate change and sea-level rise provides a powerful tool for reducing vulnerability. Planning

mechanisms can be used to direct or regulate all new investments in infrastructure, housing construction and agriculture outside hazard zones to minimize vulnerability, reduce repair costs and decrease disruption to economic activities. Involving the landowners in such planning exercises will endear them to the plans thus ensuring their long term success.

- Prohibit extractive activities from vulnerable sites of the coastal areas. Given the atoll nature of many islands, it is unrealistic to impose a general ban on all extractive activities that are largely responsible for the destruction of coastal areas of the country. However, there are some areas that are more vulnerable than others and it is these most vulnerable sites that warrant immediate drastic measures in order to stop any further damage. Construction of coastal protection infrastructure will certainly be an option but there is a need to first investigate and identify the most suitable and feasible options. Promoting the planting of sandalwood on Mangaia, Atiu and Mauke will provide a future income generating activity for these islands.
- Improve capacity and management of outer islands rainwater catchment systems. Increasing the capacity of the existing rainwater catchment coupled with better management of existing underground water resources will go a long way in meeting the increasing demand for water of the outer islands, maintain water quality and reduce the pressure on groundwater resources. These efforts, if implemented will in turn help minimize the impacts of climate change on water resources while providing immediate benefits to drought prone areas and those that are already suffering from seasonal shortages of water.
- Promote agro-forestry and other tree planting initiatives. Promoting agro-forestry regimes that enable the maintenance of the standing biomass will be an appropriate adaptation measure for areas that are already experiencing soil and vegetation loss through erosion. Replanting of littoral vegetation will help stabilize eroded coastal areas and protect settlements from wave and wind actions.
- Improve monitoring of water extraction from groundwater lens. The introduction of policies that allow the extraction of freshwater from wells to exceed certain levels only where there are no feasible alternatives would reduce the vulnerability of the local communities especially on the Northern Group to water shortages during drought.

On the basis of the vulnerabilities identified and the adaptation options discussed in the preceding section and elsewhere in this report, a national strategy for the Cook Islands to mitigate and adapt to climate change and climate variations is proposed in Table 8.

SUCCESSES AND LESSONS

Except for the lessons learned from its IWP project, there has not been a lot of effort put into documenting lessons learned from the various projects implemented in the Cook Islands. However, from the review of reports and documents made available during this assignment and through consultations held during the course of the country visit, the following can be considered as lessons from the Cook Islands experience in dealing with climate change issues as they relate to agriculture and food security.

- Population planning and migration control should be made an integral part of any national strategy to adapt to climate change. The extremely high population growth and density on Rarotonga are already frustrating national efforts to sustain supply services on the main island especially during natural disasters. More and more people are moving on to Rarotonga from the outer islands putting pressure on the coastal ecosystems, water supply and infrastructure making them more vulnerable to extreme climatic events. Government is already struggling to provide for the current population and will be in an even worse situation in ten to twenty years from now as the population on Rarotonga continues to grow. Unless government takes serious actions to control population migration especially on to the main island, the Cook Islands will face massive costs in terms of providing services and infrastructures for a densely populated capital while at the same time making sure that such infrastructure are resilient to the impacts of climate change and extreme events.
- Strengthen partnerships for effective project implementation. With several islands scattered over long distances of ocean, implementation of national projects in the Cook Islands will always be a difficult challenge. Government services are extremely limited or absent on most islands except on Rarotonga and to some extent Aitutaki and this will compound the problem. Conversely,

a handful of agencies and NGOs have been active in the outer islands and are best placed to assist government carry out some of its projects in these locations. To do this would require the establishment of effective working partnerships between the parties to ensure that their roles and responsibilities are clearly identified and understood. Similar arrangements with local communities may also prove beneficial.

- Enhance public awareness and understanding of climate change and its likely impacts on peoples' livelihood. While public awareness about global warming is improving through the media, public awareness about the impact of climate change on the peoples' livelihood is somewhat limited. Such awareness and understanding is crucial to fostering effective partnerships with local communities on efforts to adapt to climate change.
- Reduce complexity of programs and project designs. While the Cook Islands now has good capacity to implement enabling environmental projects, it does not yet have adequate technical capacity to design and implement complex, long term science-based initiatives that often require careful research and data collection. In this regard, projects and programs for the Cook Islands should be designed from the outset to be flexible and to match local capabilities to implement and manage. They should be less complex and more focused. Expected outputs should be prioritized, transparent, clear and measurable.
- Strengthening service delivery to the outer islands is crucial to nation-wide efforts to minimize the impacts of climate change on the environment and people. The high cost of transport and communication networks are hampering efforts to engage outer island communities in climate change adaptation initiatives. As a result, past climate change activities have concentrated on urban areas while those in the outer islands miss out on training and other benefits from such initiatives. Improving transport and communication links to the outer islands is crucial to the success of climate change adaptation efforts in areas that are often neglected by government programs and extension services.
- Engage local communities from the outset in climate change adaptation initiatives. Involving local communities from the outset in the planning, design and implementation of climate change adaptation projects is crucial to their success. The development of an appropriate consultative and participatory

mechanism for the government and the communities to consult with each other is an important step in formulating an efficient and effective working relationship between them.

~ Mainstream climate change mitigation and adaptation into physical planning and development initiatives. The Cook Islands NSDP does not make specific mention of climate as a goal for the Plan. In fact except in reference to the implementation of the NESAP, the NSDP is silent altogether on this most important issue. Unless climate change mitigation and adaptation are fully integrated into the planning and budgeting processes of government, these issues will continue to be addressed in a piecemeal fashion as has been in the past.

RECOMMENDATIONS

The following recommendations are considered appropriate for consideration by the government of the Cook Islands, its development partners and other stakeholders with interest in the Cook Islands.

~ Pay more attention to population migration especially on to Rarotonga. Although the Cook Islands has a comparatively low national population growth rate, migration from the outer islands has increased population density on Rarotonga to a level considered unsustainable in the long term. The problem is compounded by the high number of tourists into the islands. Existing services and facilities will not be able to cope with the demands of a growing population in the next few years and it is therefore recommended that government give more attention to controlling population growth on Rarotonga as an important part of any strategy to adapt to climate change.

~ Given the Cook Islands limited financial and technical resources, it will be impossible for the government to effectively address the wide range of issues and actions necessary to respond and adapt to climate change. Hence it is recommended that the government should strategically address a limited number of clearly identified priorities and actions based on the greatest needs and risks from climate change. Examples are water supply, coastal erosion and renewable energy.

~ Financial constraints, coupled with high transport and communication costs are hampering efforts to reach out to the farmers in the outer islands who

are especially in need of support during natural hazards such as droughts and cyclones. In this regard, it is recommended that government should consider improving service delivery and communication to outer islands as explicitly clear priorities for donor-funded development projects in future. The provision of adequate cooling facilities for the storage of fish catches and other commodities on the outer islands while awaiting shipment to the markets on Rarotonga will also need careful consideration.

~ The agricultural research station has provided the foundation for the success of the agriculture sector in the past. The loss of the station on Rarotonga is therefore a big blow to efforts to once again make agriculture a major contributor to the Cook Island's economy. It is therefore recommended that efforts should be increased to ensure that plans for the re-establishment of the research station on Mauke are realized as soon as possible.

~ GEF-funded national and regional climate change related projects in the past decade have provided a wide variety of training and human resource development in the Cook Islands. FAO, SPC, SOPAC and the EU have also supported capacity building initiatives in agriculture and these have contributed enormously to building the country's overall capacity to address environmental and agricultural related national concerns while at the same time also meeting the country's obligations under international regional and international agreements. However, due to the high rate of occupational mobility, retirement and migration, it is recommended that human resource development initiatives be continued and expanded if the Cook Islands is to be able to deal with the growing and complex issues associated with climate change.

~ Although the local markets for locally produced crops and vegetables are good, there are limited opportunities for fruit trees such as citrus, pawpaws and mangoes. The absence of processing facilities for these crops means that the fruits are left to rot and wasted. In this regard, it is would be useful for the government to encourage investment by the private sector in the processing of fruit crops into more marketable commodities such as juice that have longer shelf-life and are easier and lighter to transport. Processing can also create job opportunities for many young people who are presently unemployed.

- The most immediate threat to the health of the marine environment of the Cook Islands especially on Rarotonga at present comes from the adverse impacts of hotel and settlement construction on the foreshores. How much of this threat is already taking place is evident from the amount of soil and beach erosion that is occurring throughout the islands. How this erosion is affecting the health of the marine environment is not known and there is an important need therefore to carry out comprehensive studies and surveys to determine how and to what extent coral and coral reefs are being affected by land-based developments. Equally importantly, it is desirable to determine on the basis of the findings of the studies how future climate change and sea-level rise would add to the existing situation.
- Some farmers and local residents have noted changes not only to the fruiting season of some fruit trees but also in the yields of traditional root crops in recent years. Whether these changes are directly related to climate change and climate variability is not known although many speculate that there is a connection. Affirming the links between climate change and changes in crop production and behavior will go a long way in improving peoples' understanding of climate change issues and in enhancing efforts to involve local communities in the implementation of climate change adaptation strategies and plans. To this end, it is recommended that more risk-based adaptation approaches to climate studies should be undertaken coupled with public awareness activities to increase peoples understanding of climate change and climate adaptation measures appropriate to the Cook Islands.

CONCLUSIONS

It is evident that development and social changes have placed pressure on sensitive environmental systems and sectors of the Cook Islands and hence, adverse impacts of anticipated climate change and sea-level rise will add further stress on these systems. Agriculture and food security, coastal zones and coral reefs, marine resources, water resources and biodiversity are already vulnerable to the adverse impacts of climate change and the situation will get worse until the global community commits to drastic reductions to current levels of GHG emissions.

The Cook Islands has already experienced first hand the adverse impacts of climate change and extreme events. In 2005, the islands were hit by five tropical cyclones within the space of one month, an event that has never been experienced in the history of the Cook Islands. In 2005, the island of Pukapuka was completely inundated by wave surges associated with cyclone and strong winds causing the loss of agriculture land which took three long years to recover. Droughts are also reported to be on the increase and some previously productive lands have become boggy and hard to work as a result.

People interviewed during the course of the study stated that it is now common to harvest some crops more than once a year as they are flowering and fruiting a lot earlier than normal. It was also mentioned that mosquitoes are now rife in places where they were previously not found in some islands in the Northern Group. Cook Islands has had a dengue fever epidemic in the past and it is likely that climate change will bring about a repeat of this epidemic. Heavier than usual rainfall in the Southern Group is also reported to have resulted in the increase of fungal diseases affecting pawpaws and other tree crops.

People and infrastructure located close to the coast are already threatened by rising sea levels and storm surges. Coastal erosion is evident almost everywhere on the island of Rarotonga thus threatening the country's tourism industry which is heavily based on the beaches and sea. The problem is compounded by the ongoing conversion of coastal lands for settlement and hotel development. These developments are therefore contributing to their own unfortunate demise as climate change related events will threaten the coastal areas and lands on which they are located.

In 2007, tourist numbers in the Cook Islands reached 97 000, almost double that of 1998 when visitors numbered 50 000. It is the largest contributor to the country's GDP. Its contribution was 56.5 percent in 2006, and 60.3 percent in 2007 and creates employment for around 700 people in the hotels/motels sector. Climate change could compromise all this by causing damage to the natural environment upon which the industry is dependent.

The Cook Islands has taken important steps to adapt to the impacts of climate change and climate variability. A National Climate Change Country Team (NCCCT) has been formed and a number of strategies and action plans have been prepared

and adopted for joint implementation by various government agencies, NGOs, and other partners. Vulnerability and Adaptation assessments have also been done for some islands (Aitutaki, Mangaia and Penhryn) with more to be undertaken as part of preparations for the Second National Communications (NC) report.

The above actions are important and necessary to enable the Cook Islands to effectively adapt to the impacts of climate change. However, there is more to be done. At the country level, funding is needed to implement the various strategies and plans that have been developed and to carry out vulnerability assessments of islands earmarked for the Second NC report. Public awareness and training need to be increased to and partnerships developed to engage expertise and resources available from other stakeholders. Additionally, there is a need to mainstream climate change into the national sustainable development plans and strategies to ensure that there political support for action and to make sure that adaptation and mitigation plans do benefit from the allocation of national budgetary resources.

At the regional and international levels, there is a need for the Cook Islands to engage in dialogue with other PIC leaders as well as leaders of other small island states about what the Pacific and the small island states want out of the post-Kyoto negotiations. Like other PICs, there is also a need to commit to the implementation of the Pacific Islands Framework for Action on Climate Change 2006–2015 which provides a strategic platform not only for use by policy and decision makers at all levels, but also for the development and strengthening of partnerships for implementation of national and regional initiatives.

All these and more is required to ensure that the Cook Islands is well prepared to adapt and deal with the adverse impacts of climate change.

TABLE 8: **PROPOSED STRATEGY TO MITIGATE AND ADAPT TO CLIMATE CHANGE**

CLIMATE CHANGE ISSUE AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
	ROOT CROPS	
Declining crop production	~ Re-establish the agriculture research station on Mauke as a matter of priority ~ Support agriculture research and breeding of drought resisting varieties ~ Increase public awareness about climate change ~ Promote adaptive management approach ~ Support Young Farmers initiative of MOA ~ Support early warning system especially for outer islands radio network for better exchange and sharing of information	~ Increase support for plant breeding programme ~ Encourage agro-forestry practices using traditional crops ~ Carry out research on farming systems including soil/land/ animal husbandry ~ Identify and select cultivars that are tolerant to abiotic stress ~ Broaden genetic base of traditional food crops ~ Revitalize traditional gardening practices (e.g. rotation planting) and integrate with modern practices where feasible and profitable ~ Improve farm irrigation systems ~ Promote composting as an alternative to commercial fertilizers where possible
Increased pest activities due to changes in temperature and rainfall	~ Promote adaptive management and risk-coping production systems ~ Review quarantine control measures for distribution and propagation of food crops ~ Strengthen research capacity of MOA and private farmers ~ Raise public awareness about risks from introduced pests and diseases	~ Concentrate on crops and cultivars with pest and disease resistance traits ~ Avoid monoculture where possible ~ Broaden genetic base of traditional crops ~ Build capacity of border control agencies such as quarantine, customs and police ~ Increase collaboration with neighboring countries including New Zealand on pest and diseases control measures

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[→] Table 8 continued

CLIMATE CHANGE ISSUE AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
Salt spray and rising sea levels affecting home gardens and crops	~ Impose restrictions on clearing of coastal vegetations ~ Develop and adopt a national land use plan ~ Develop coastal infrastructure management plans ~ Develop policy to guide development of coastal areas ~ Review EIA legislation to ensure effectiveness under current circumstances	~ Move gardens away from vulnerable / exposed sites ~ Plant littoral vegetation as buffers against salt spray ~ Regulate and control activities along coastal area ~ Control mining of sand from the beaches ~ Undertake cost/benefit analysis of various coastal protection measures ~ Adopt agro-forestry practices where possible
Shifts in weather patterns affecting planting and harvesting regimes	~ Improve exchange and sharing of information between Weather Service, MOA and planters ~ Develop and apply adaptive management and risk-coping production systems ~ Raise public awareness about changing weather patterns and impact of agriculture	~ Adjust planting and harvesting regimes to prevailing conditions of past 3–4 years ~ Undertake assessment of changing weather patterns o traditional crops ~ Support crop improving programme focusing on climate change adaptation ~ Monitor changes in crop behavior in relation to shifts in weather patterns
FRUIT TREES		
Shifts in weather patterns affecting flowering and fruiting seasons	~ Improve sharing of weather information with fruit tree farmers ~ Monitor and document flowering and fruiting behavior of fruit trees	~ Adjust harvesting regimes to existing conditions and circumstances ~ Improve storage facilities to keep excess harvests ~ Consider local processing for excess and low quality fruits for juice and jam production
Increased rainfall creating favorable conditions for fungal diseases affecting fruit trees such as pawpaws	~ Support research on pests and diseases affecting fruit trees ~ Share information on pests and diseases affecting fruit trees	~ Identify species and cultivars that are resistant to fungal diseases ~ Apply appropriate pest and disease control measures ~ Promote agro-forestry practices and avoid monoculture where possible ~ Support crop improvement programme focusing on climate change adaptation

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[→] Table 8 continued

CLIMATE CHANGE ISSUE AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
	FISHERIES AND PEARL INDUSTRY	
Increased sea temperature could affect biological properties and distribution of fish species thereby affecting fish catches and hence food security	~ Monitor impact of sea temperature on fisheries resources ~ Provide support to enable implementation of fisheries management plan	~ Carry out research on the impacts of rising sea temperatures on coral reefs and fisheries ~ Promote and enforce sustainable coastal management practices ~ Adjust fishing efforts and catches according to state of stocks ~ Provide proper cooling and storage facilities to enable fishers to store their catches for low seasons
Increased pollution from beach and soil erosion during cyclones causing damage to corals and reefs	~ Improve public awareness about connection about climate change and health of marine environment	~ Implement coastal erosion protection measures ~ Monitor health of reefs and lagoons ~ Manage and control land based activities that are affecting resilience of coastal areas ~ Where possible relocate houses and other infrastructure from vulnerable areas
Limited understanding of the impacts of climate change on fisheries resources	~ Develop climate change awareness programs based existing knowledge targeting politicians, schools and local communities ~ Incorporate climate change subjects in school curriculum	~ Continue studies on impact of El Niño events on tuna stocks and oceanic fisheries in general ~ Collect and document evidence of changes in fisheries to enable better understanding of climate change impacts on the resource

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[—>] Table 8 continued

CLIMATE CHANGE ISSUE AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
	WATER SUPPLY	
Increased salinity of ground water sources resulting from salt water intrusion, overuse and droughts	~ Develop water management and conservation policies specifically tailored for periods of droughts and severe water shortages ~ Promote sustainable water conservation and utilization practices ~ Include water storage measures in design of major buildings especially in northern group	~ Increase rain water catchment and storage capacity especially in northern group ~ Control water usage during dry spells ~ Carry out regular water quality tests from ground wells to ensure safety for human consumption ~ Plant littoral vegetation as protection from salt water intrusion ~ Conduct water conservation awareness workshops and trainings
Prolonged dry spells may affect capacity of water supply to meet dry-weather demands	~ Develop policies to enforce rainwater harvesting, storage and conservation ~ Promote water efficient appliances	~ Incorporate rainwater catchment and storage in design and construction of major buildings ~ Regulate use of irrigation systems ~ Conduct water conservation awareness workshops and trainings
	FORESTS AND TREES	
Increased pest activities due to changes in temperature and rainfall	~ Promote adaptive management and risk-coping measures ~ Review pest control measures and species selection practices	~ Apply appropriate pest control measures ~ Adopt multi-cropping to avoid widespread of pests and diseases ~ Promote tree species with pest and disease resistance traits
Loss of tree growth due to drought and high temperature causing heat stress	~ Promote adaptive management practices	~ Promote drought resistant tree species ~ Prevent forest fires when they occur ~ Monitor tree growth during droughts
Loss of vegetation due to wave activity and flooding	~ Raise awareness about the role of forests and trees in protecting islands and environment ~ Develop policy for management of coastal areas	~ Replant littoral vegetation to stabilize eroded lands ~ Promote tree planting with schools and communities ~ Construct coastal protection measures

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[→] Table 8 continued

CLIMATE CHANGE ISSUE AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
	LIVESTOCK	
Increased temperature could affect health and reproductive efficiency of livestock	~ Train livestock keepers on proper care for their animals ~ Monitor health of livestock during extreme weather conditions	~ Keep animals in pens and in shelters away from coastal environments ~ Ensure adequate water supply for domestic animals
High rainfall could result in increased incidence of animal diseases.	~ Monitor health of animals during extreme weather conditions	~ Keep animals away from water-logged areas ~ Strengthen veterinary services to reach outer islands

*Assessment on the Aitutaki Crops Loss/Flooding and Coastal Erosion by Cyclone Meena, Nancy and Olaf**

The following is Bobby Bishop's assessment on the number of crops lost and coastal impacts as devastated by the three cyclones that came our way. The report is a combined effort produced with the assistance of the Aitutaki Department of Agriculture.

Of the three cyclones, Meena and Nancy's pathways were most destructive, and this is evident in the damage caused to the infrastructure and homesteads, natural forest, inland/foreshore vegetation, and coastal areas, by wind, waves, and erosion. Olaf had less significant impacts on Aitutaki, although it added stress to already strained infrastructure and ecosystems.

According to the assessment carried out by the Department of Agriculture, it appears that other than fruit trees, crops such as root crops received minimal damage because they were too small. Fresh food shortages will be a problem taking into consideration the loss of bananas and pawpaws and the supplies of many fruit trees.

Introduction

~ Cyclone Meena's full striking force hit Aitutaki at about 2.00 am, Sunday 6 February, from the North-West direction. Highly destructive winds were experienced. Apparently crop damage on both coastal and inland areas was more severe on the North-West than on the leeward South-East end.

~ Cyclone Nancy had its full force hit the island at about 11.30 pm Monday 14, with almost the strength of Meena. But this time destructive winds with force were coming from the eastern side of the island, and battered Akitua Resort the most. Crop damage on both coastal and inland was severe on the eastern side of the island. There were fewer impacts on the coastal area of Vaipeka to Tautu, because the small islets and more distant barrier reef provided protection from big swells.

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* By the Environment Service, Tu'anga Taporoporo, 22 February 2005.

Fruit trees

Coconuts

- Nut loss and leaf damage were severe, along with a few scattered fallen trees. Although some fruits are still hanging on the trees, it is expected these will fall prematurely.
- It should also be noted that the community cutting down trees in the villages before the Cyclones, caused more tree loss than the cyclone.
- Overall damage would be within the vicinity of 60–70 percent.

Mangoes

There were quite a number of trees in some areas on the island loaded with fruits that would have been ready in March/April, all went to waste during the cyclone. Close to 100 percent of fruit are now on the ground.

Bananas

This is one of those plants very prone to damage and particularly vulnerable to strong winds. Up to 100 percent fruit and tree loss.

Breadfruits

Breadfruits at this time were ready and in abundance, sadly up to 100 percent of the fruit were lost to the ground.

Natural trees and vegetation

- Surprisingly the natural trees or forestry were the area of greatest concern and devastation caused by the cyclones.
- Main tree species damaged were pistach trees, au (wild hibiscus) trees, big mango trees, in both foreshore and inland areas.
- Everywhere there are noticeable branches piled up under the tree with the standing trees almost half naked. This especially the case for pistach trees.
- Foreshore dominant trees affected are coconut and Au trees, and the worst area where trees were uprooted was on the western side of the island.

Coastal erosion

- There was a huge shift of sand from the north-eastern side (airport) of the island towards the southern coastline.
- Accommodation such as Are Tamanu, Manea Beach Villas beachfronts experienced sand erosion on their beach, while surprisingly the nearby Pacific Resort was getting all the sand accrual from the cyclones.
- Akitua and Samade Bar faced the same problem of coastal erosion, new coconut trees, some uprooted while some are barely trying to stand with roots exposed to the hot sun. An estimated total of almost 90 percent of the coast showed evidence of erosion, whereby sand, soil, and coastal vegetation was shifted during the cyclones.

Flooding

~ The worst affected was the low-lying areas along the western side of the island and Akitua/Samade Bar.

~ Sea surge went about 60–70 metres inland around some areas. Rapae streams were blocked from debris and sand closing the mouth of the stream causing water to back flow into the Amuri School ground and peoples property, resulting in smell from the rotting debris.

TABLE 9: **ESTIMATED LOSS OF CROPS FRUIT, TREES AND COASTAL EROSION**

CROP		PERCENT LOSS	REMARKS
FRUIT TREES	Coconuts	60 percent fruit loss	Few scattered fallen trees
	Mangoes	100 percent fruit loss	Branches stripped off
	Bananas	100 percent fruit/trees loss	Wind and salt Spray
	Breadfruits	100 percent fruit loss	Mainly Tahitian variety
NATURAL FOREST		50 percent by cyclone 45 percent by community	Severely damaged
COAST EROSION		90 percent shows signs of sand being shifted, trees undercut	Affects tourism accommodations the most, unstable sand needs vegetation cover to prevent further erosion
FLOODING		60 percent area damaged	Fallen branches, sand and debris stopped water from flowing in the streams, overflowed into houses along the coast, sea surge affected some left over home appliances. Waves went about more than 60 metres inland

Conclusion

The damage caused by the cyclones has and will continue to affect both subsistence and commercial crops, particularly in areas where salt spray and inundation by storm surge mean ground water and soils are now less suitable for growing.

The costs of the cyclone will be felt for some time on the island with particularly huge impacts to the tourist accommodations that had their beaches are severely eroded and some damage to units and equipment.

The amount of trees being cut down by communities and destroyed by the cyclones could require a tree-planting programme for the island, as natural vegetation often provides a good barrier to the elements and tree roots help hold the soil and slow erosion, as well as enhancing the attractiveness of the island.

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