AITUTAKI

CLIMATE CHANGE COMMUNITY VULNERABILITY AND ADAPTATION ASSESSMENT REPORT

Conducted 2003

Prepared by
Pasha Carruthers & Bobby Bishop

Capacity Building to Enable the Development of Adaptation Measures in Pacific Island Countries, Cook Islands (CBDAMPIC)

CBDAMPIC
our islands
our lives

Executive Summary

Observations by Pacific Island Communities including Aitutaki indicate that predicted climate change impacts are being felt now, making the need to respond a pressing concern not a distant future scenario.

In an effort to improve the ability of people to understand and cope with the effects of climate variability and change, the Canadian International Development Agency (CIDA) and South Pacific Regional Environment Program (SPREP) initiated a three year programme to document pacific communities' perceptions of some impacts of and responses to, climate change and sea level rise that are likely to increase in coming years. This report summarises a range of potential solutions identified during research and consultations on the island of Aitutaki in the Cook Islands and looks at the first steps for a local adaptation option to be implemented as a pilot project in one focal area, namely fresh water resources.

The Cook Islands Government will submit this community vulnerability and adaptation report to CIDA, in conjunction with a pilot project-funding proposal on rainwater harvesting, thus ultimately developing a grassroots process for responding to climate change and communicating the problems on the ground to the international community.

Information in this report was provided by extensive community consultation though village meetings, committees, and one to one interviews. As a result, these findings and recommendations are a clear indication of what is feasible for Aitutaki in the current context of climate variability and change. Also apparent are the constraints to adaptation without assistance, such as a lack of resources, limited access to suitable technology, limited expertise to develop and maintain adaptation options, and until recently limited awareness that changes being experienced on the island are a reflection of broader global processes.

In contrast to other outer islands in the Cook Islands, Aitutaki has been the subject of a number of useful baseline studies and reports, summarised in the first section of this report and expanded as annexes. Hence expert judgement and prior research studies were used to enhance the community identified climate change impacts and response options, particularly for prioritisation and cost benefit analysis of adaptation options. Uncertainties exist over whether currently observed changes such as temperatures, rainfall patterns and sea level will increase rapidly or gradually. However the current limited capacity to adapt and constraints/restrictions on developing capacity to adapt are clearly a concern.

In terms of what causes the climate related issues to be a problem and how it affects the villages, the vulnerability section of this report concentrates on the sensitive sectors identified by members of the Aitutaki Climate Change Community Team made up of government departments and stakeholders, who included the sectors of water, coastal areas, health, agriculture, biodiversity, tourism, and energy amongst other cross cutting issues.

Under socio-economic projections the local population decrease is an unusual factor relative to world trends and means fewer resources including labour are available for adaptation, and there may be declining services affecting sustainability of current development. Aitutaki does have some high ground meaning the people are less at risk of losing their lives in cyclones compared with the lower lying coastal habitations on other Cook Islands, provided they follow their disaster management procedures. Past experience has proved primary damage is to tourist accommodations, homes, vegetation and port infrastructure.

There is limited capacity in Aitutaki to cope with the present impacts and growing importance of climate variability and this is likely to worsen under climate change coupled with non-climatic factors such as land use change and tourism growth.

Based on community consultation outcomes, current sensitivity to climate and therefore the areas likely to be most impacted by climate change unless there is adaptation on were found to

be water resources, the coastal zone, and agriculture, from the manifestation of drought, storm surge, erosion, and salt water intrusion.

A range of coping mechanisms and potential adaptation options are presented for the different sectors. Initial recommendations include a focus on improving rainwater catchment and storage, diversification of agriculture cash and subsistence crops to foster self sufficiency while attempting to control pests and introduction of invasive species, improvement of the climate monitoring in Aitutaki, and expansion and scientific verification of observations presented in this report.

In sum the community consultations provided the opportunity to obtain baseline data and raise awareness of climate change issues amongst the local community with whom ongoing consultations will be important for determining appropriate response options to future climate change impacts. It is hoped that through assessments such as this the people of Aitutaki will be able to use the precautionary approach to climate change impacts and integrate wise practices in that context

Summary of Recommendations

The community's choice of rainwater harvesting improvement though the provision of water tanks is described, and possible ways forward explored. The CV&A assessment had also collected wealth of information regarding the vulnerability and coping capacity of the people of Aitutaki to agriculture, health and the tourism sector. The Department of Environment in collaboration with the Aitutaki Island Council, women's groups and schools will take the initiative to explore funding opportunities to implement these adaptation recommendations at a later stage.

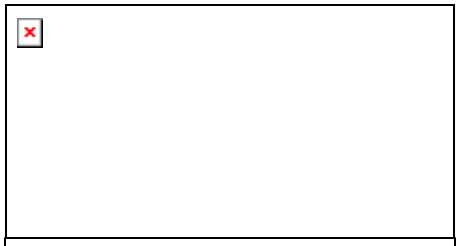
Acknowledgements

Aitutaki (Araura) was selected for the CBDAMPIC Community Vulnerability and Adaptation (V&A) Assessment through consultation with the Ministry of Outer Island Development (OMIA), Environment Service, the Cook Islands National Climate Change Country Team[1], and other interested parties. Wayne King, Diane McFadzien, I'o Tuakeu Lindsay and Tania Temata were instrumental in recognising the need for 'on the ground' work towards an adaptation option implementation and driving the submission process. The CBDAMPIC validation mission team, particularly Barry Smit refined project details, while Taito Nakalevu of SPREP has facilitated all aspects of the project since its commencement. Taito Nakalevu along with Ian Fry, John Hay, Chris Cheatham and Diane McFadzien gave invaluable comments on various aspects of the CV&A.

In Aitutaki the Aitutaki Climate Change Community Team (ACCCT) was formed at the start of the project to guide the development of the pilot adaptation project component. Ron Maki is the chairman, with other members representing the Island Council, youth, women, education, health, water, tourism and the private sector. Also a Core Group of village-based representatives was trained to facilitate the community consultations as this program is developed. The hard work of these two groups allowed the officers to produce this island-specific CV&A report to enable the development and implementation of one of the identified adaptation options in Aitutaki.

The work objectives would not have been achieved without the kind and informative assistance of Teokotai Herman, Mayor of Aitutaki, John Baxter, Deputy Mayor, and Tarota Tom, former Island Secretary. In addition the Agriculture Growers Organisation, Aitutaki Island Women's Association, the teachers at both primary and secondary schools, and many other community members input and opinions gave form to the qualitative description of current situations and climate sensitivity on Aitutaki, which will be useful to measure future climate change impacts, and helped identify response options to changes.

Having a locally based CBDAMPIC Coordinator, Bobby Bishop, proved invaluable for the smooth organisation of the community consultations, Maori translations, and ongoing communication with local decision makers on Aitutaki. Several visits to Aitutaki provided Technical Advisor Pasha Carruthers with an important opportunity to verify the published data; provide public education on climate change; and participate in the community consultations that were essential to understanding climate related concerns on this 'almost-atoll'.



• Figure 1 Cook Islands Core Team 2003

Purpose of CBDAMPIC

The Capacity Building to enable the Development of Adaptation Measures in Pacific Island Countries (CBDAMPIC) programme aims to improve the ability of Pacific Islanders to understand and cope with effects of climate change and sea level rise. By engaging the communities and piecing together anecdotal and scientific evidence, the project hopes to develop a model process of how to develop climate change responses. Although the project is only being carried out on one island each of 4 unique pilot countries (Cook Islands, Fiji, Samoa, Vanuatu), the process of developing community appropriate responses in Aitutaki should be transferable to other islands and priorities in the Cook Islands and the wider Pacific. Therefore, decision makers and institutional arrangements (who does what, identification, prioritisation, and approval of both impacts and solutions) also need to be involved and clarified.

[1] This is a team, made up of representatives from different government ministries & departments including Water, Agriculture, Health, Energy, Marine Resources, Environment Services, Meteorological Services, Foreign Affairs, Disaster Management formed for the PICCAP.

Purpose of the Community Vulnerability & Adaptation Assessment (CV&A)

Specifically the Community Vulnerability and Adaptation Assessment was conducted to make it possible for the people of Aitutaki to tell the CBDAMPIC project team what climate related problems Aitutaki may be experiencing, and to gather ideas of how to cope with climate related issues both now (climate variability) and in the future (climate change) at the local level.

The CBDAMPIC project is striving to be more than a study, and to actually implement a community identified adaptation option. Therefore this report will serve as a basis for identifying practical and locally appropriate solutions that can be implemented as a pilot adaptation project funded through CIDA. The report also provides a tangible outcome of the community consultations that the Aitutaki people can respond to and explore further.

Vulnerability Characterised

Vulnerability can be defined as how much an 'at risk' area is affected or disrupted by climate change. Vulnerability therefore is more than just how exposed to risk you are, but also incorporates your ability to cope with that risk. When you adapt (take steps to respond to the risk) your vulnerability is reduced. Sometimes there is the potential for complete adaptation, in which case you will no longer be vulnerable to that risk, in other situations for various reasons you may not be able to do anything to respond to the risks, or the response option (such as abandoning your traditional home to rising seas) is unacceptable. In this case you are considered vulnerable to climate change.

Aitutaki is the only 'almost-atoll' type island in the Cook Islands, having mostly sandy low lying atoll characteristics but retaining some volcanic hills and soil, and is very different from both the high volcanic island of Rarotonga and the raised limestone (makatea) islands in the rest of the Southern Group. The 'almost-atoll' type of island is considered to be more sensitive to climate in the present[2] due to the dependence on agriculture and coastal resources including groundwater, and it was not clear what the coping strategies for climate change over the coming century would be.

Framework of Study and Analysis

To approach climate change impacts solely in terms of the island's climate, geography, geology, and topography is to overlook the key reason behind our vulnerability assessment, helping the people understand and cope with climate change. This study is undertaken using the participatory approach because climate change affects livelihoods, therefore the views of the people need to be taken into consideration. The community consultations provided a clearer picture of how the vulnerability of an area is usually related to the potential impacts on human activities or livelihoods in that area, and what proactive steps towards adaptation are feasible from a local perspective.

Not having conducted any participatory approaches before, the community consultations were 'learning by doing' exercises for the CBDAMPIC Aitutaki team and consequently the timing and information gathered improved sequentially. The methodology and outcomes on a village-by-village basis (minutes) are annexed. Key features were the lack of a formal climate change presentation during the meetings to ensure the process was as open to local perspectives of climate related problems as possible, the use of the local language and village based facilitators, and the consistency of results found between villages.

Despite efforts to source as much information as possible the vulnerability baselines are not complete, as time demands on the community had to be limited to four-hour village meetings. The challenge here was to synthesise the feedback from almost 200 individuals and eight separate villages into a report format that goes beyond a simple list, and integrates other relevant research such as field observations, individual interviews, and independent research.

[2] Climate sensitivity is related to exposure and frequency of conditions that require responses.

Gaps in the adaptation needs and current coping mechanismsare found because technology and scientific data for more quantitative reporting were not complete or up-to-date for some aspects of this study, although interviews with local researchers[3] and a literature review enhanced the community views expressed.

The authors trust that the community still recognises their input with some value added by analysis based on similar cases in other small islands and expert judgement. Note that crosscutting issues prioritised in community meetings, such as droughts, floods, cyclones and storm surge (extreme events), and pollution have been incorporated into livelihood-oriented sectors such as coastal, agriculture, and health. Because the communities prioritised what was important to them at the consultation time rather than what might become important in the future, not all adaptation needs of Aitutaki are likely be reflected, and this was beyond the scope of the 'bottom-up' pilot project component.

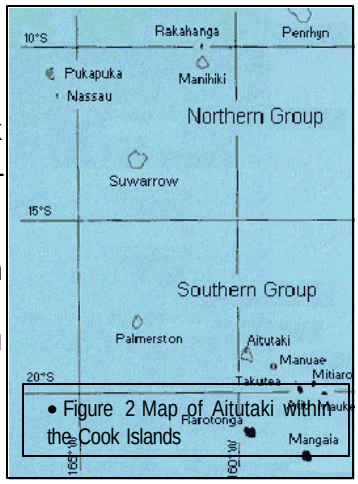
The adaptation assessment section focuses on adaptation solutions both identified by communities, and that are practical and appropriate to undertake in the present, while improving the sustainability of Aitutaki livelihoods. By enabling the community to identify such solutions themselves through the consultation process, it is hoped that Aitutaki's capacity to proactively implement adaptation measures has been built.

[redacted]

[3] For example former teacher Retire Puapii's high school program of water quality tests had indicated unhealthy levels of E coli in water tanks

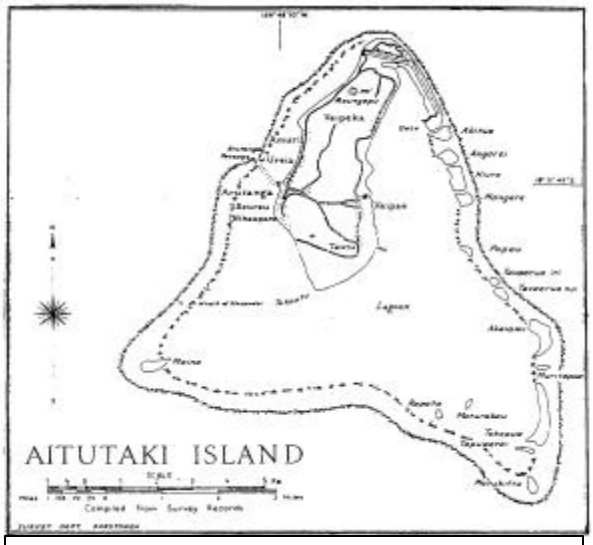
Background Information

Physical and Natural Environment of Pilot Community



• Figure 2 Map of Aitutaki within the Cook Islands

Aitutaki, also known as Araura Enua, is triangular in shape and the most geologically unique island of the five island systems in the Cook Islands being part volcanic and part atoll[4], with a total land area of 18.1 km^2. Aitutaki is one of the nine southern group islands of the Cook Islands, situated at latitude 18°51' south and longitude 159°48' west, 259 (277) kilometres north-east of Rarotonga and 210 kilometres from its nearest neighbour Atiu. Aitutaki rises to about 121 meters above sea level at its highest point ? Maungapu. Aside from the Maungapu the island consists of flat-topped terraces, fertile planting areas, and extensive areas of coral sediment.



• Figure 3 Map of Aitutaki Island

As Figure 2 indicates, the lagoon is 66 sq km encircled by over 40 kilometres of reef studded with 15 additional islets (motu), and has an average depth of about 5 meters. There is no deep-water passage into the lagoon. Areas of the lagoon are now under "Raui" (a traditional conservation method) where marine activities are not permitted for given periods. This is to assist the re-establishment of the native clam population as well as reef fish. The islets are also breeding grounds for endemic birds such as lorikeet, but habitat changes and invasive species such as rats are a threat. More detailed information about the geology, flora, and fauna is annexed.

SOCIO-ECONOMIC ENVIRONMENT OF PILOT COMMUNITY

Population Demographic Trends:

The second most populated island of the Cook Islands, the small landmass means the eight villages, namely Amuri, Nikaupara, Reu Reu, Ureia, Vaipae, Vaipeka and Tautu, are quite densely populated. The resident population, made up of Aitutaki Polynesians with a small number of expatriates and holders of work permits, was estimated to be close to 1,800 in March 2003, compared to the 1996 figure of 2,272 (Table 2). The 23% drop in population was concentrated in the age groups of under 5 years and 20? 29 years.

People live around the coast where the economic centres and activities are situated, falling into four census districts - Amuri-Ureia, Arutanga, Tautu, and Vaipae-Avanui. The total number of dwellings in 2001 was 452, with an average size of 4 persons. The main settlement is Arutanga, which is also the administrative centre of the island.

Table 2: Population

1971	1981	1991	1996	2001
2855	2355	2357	2272	1743

Source: Cook Islands Statistics Office.

[4] Five different island systems described in the Pacific Basin: high volcanic; low volcanic surrounded by a raised reef platform or makatea; volcanic partially submerged with a large atoll-type lagoon or almost atoll; the true atoll; and sand cays.

The population continues to decline as many working age people migrate for better opportunities either to the main island (Rarotonga) or to New Zealand and Australia[5]. Population increases or decreases affect environmental health and vulnerability, particularly in the health and water sectors, and the effectiveness of adaptation options. In assessing future effects , scenarios of future demographic change and socio-economic development need to be consistently woven alongside scenarios of climate and sea level change[6].

Land Tenure

Aitutaki society follows a system of rankings, and ariki and sub-chiefs uphold their authority to make decisions on land. In general, the responsibility for maintaining authority in the household rests with the father or eldest living male of the family. Succession to land can be by bilateral inheritance, ensuring that every member of a family has rights and shares in family plots of land[7]. Practically all the land on Aitutaki is held under one or other of two common titles. The first type is native customary tenure, whereby lineage or family groups hold land under Aitutaki custom. The second type is native freehold which is land held according to custom but for which the Land Court has determined ownership[8]. No foreigner can own land, they may purchase leases to a maximum of 60 years. Aitutaki's land tenure systems will affect future patterns of population distribution, tourism, and infrastructure development, which in turn can worsen or improve vulnerability to climate.

• Figure 4 Fenced property

EDUCATION STATUS

Aitutaki is in line with the rest of the Cook Islands' high literacy rates of over 90% and had five schools in 2001. However, Amuri School was closed down in 2002 due to falling enrolments. Falling rolls are of concern generally, along with the lack of higher educational qualifications. This lack of higher education could limit capacity to deal with climate change impacts.

Sources of Livelihood, Economy, EMPLOYMENT AND INCOME

In general, some division of labour observed in traditional times remains, with men being responsible for fishing, tending animals, planting, building houses and canoes; and women being responsible for cooking food, processing raw materials for weaving, and child rearing and caring. Today, women are more involved in home and crop gardening and some cash crop activities. Also women have taken up opportunities to operate private businesses, and/or support family initiatives in this area. People engaged in full time employment have increased and in 2001 54% of over 15's were classified as economically active in the sense that they were employed (519 people) or unemployed but seeking work (84 people).

The Aitutaki economy is largely based on tourism and agriculture production. Tourism is the largest contributor to the economy of the island, succeeding agriculture, which was once the mainstay of the economy. Selling of subsistence agricultural products like vegetables has remained even though the banana export industry collapsed in the late 1980's with international competition, irregular shipping services, high costs of pest and fungal control, and damage from cyclones. The export of trochus shells used in jewelry and button production overseas and selling of other marine life is an additional source of income. Remittances are very important to Aitutaki's economy with relatives working overseas often sending money home or investing on the island by building homes for when they return.

---

[5] Exact birth, mortality, migration, and population figures are not available for Aitutaki
[6] Warrick, Richard, IGCI, addressing a climate change workshop for the Alliance of Small Islands States, Apia Samoa, August 2, 2000
[7] Crocombe, R., (1987).
[8] Beaglehole, E., (1957).

• Figure 5 Tourism Services, Day boat tours and entertainment

Public service numbers have dropped since 1996 and private sector employment has expanded, providing 54% of employment in 2001, while the public service provided 22%. There has been a marked rise in employment with non-government, including overseas, organizations. Several researchers have made comments about reliance on government and external assistance for both economic development and resource management. However, our assessment team found that a 'do it ourselves' attitude was becoming more prevalent, and in fact the Island Government was determined to handle decision-making requirements themselves.

• Figure 6 Bananas the former top export and industry

A **Household Income and Expenditure Survey** of Aitutaki was undertaken by the Statistics Department in 1999. This showed that average weekly household income from all sources such as subsistence production, wages, and welfare, closely matched average weekly household cash expenditure on food, housing, and transport. In December 2002, there were 623 welfare (child benefit, disability, old age pension) beneficiaries representing 35% of the population. This means Aitutaki people are unlikely to have financial reserves or to purchase insurance to protect from climate change impacts.

Banking services are provided by branches of the Bank of the Cook Islands, Westpac and ANZ, and the island will have its first cash machines in 2004. There is a local market every morning except Sunday, which offers vegetables, coconuts, clothing and handicrafts. The market building also serves as a general meeting place.

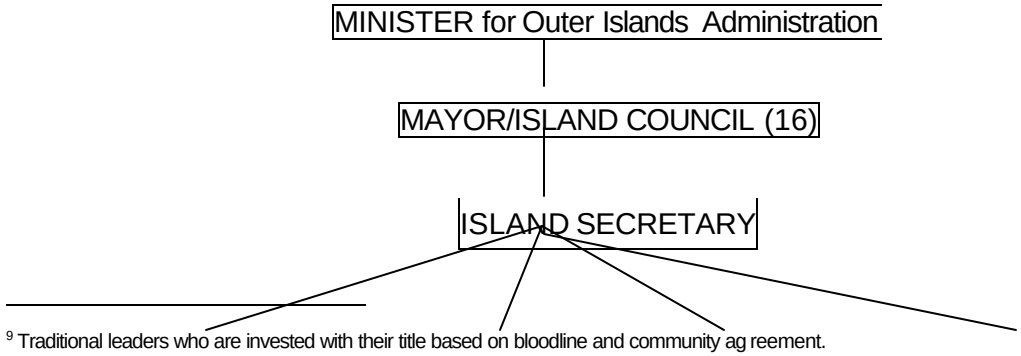
Local Governance on Aitutaki

ADMINISTRATION

The Island Council consists of the Mayor, who is the head of the Council, plus eight other members representing the 8 villages on Aitutaki. Elections for the positions of Mayor and the Council members are held every three years. Included in the Council are three Arikis, a representative of the Mataiapo[9], and the three Members of Parliament. The Island Secretary heads the administration unit and he or she is recommended by the Council through Cabinet and appointed by the Public Service Commissioner. The administration unit is accountable and responsible to the Council through the Mayor in accordance with a performance contract. The Island Secretary reports to MFEM and the PSC on required matters.

Figure 1 presents the administration's structure and numbers of employees, which total 54. In addition, there are public servants on Aitutaki employed by line ministries. The latter include Police, Internal Affairs, Justice, Education and Health.

• FIGURE 1: AITUTAKI ADMINISTRATION STRUCTURE



[9] Traditional leaders who are invested with their title based on bloodline and community ag reement.

Finance & Administration (4) Energy (19) Infrastructure (27) Women & Youth (3)

The Island Government is currently reviewing their Strategic Action Plan[10], and has agreed to implement the 2003 Environment Act, which requires Environmental Impact Assessments for large developments to be approved by a newly formed Island Environment Authority. Included is potential for incorporation of a series of Resource Management By-laws covering waste management; habitat and species protection; wandering animals; and general environmental issues[11]. Provided they are enforced, implementation of such bylaws would alleviate some of the human pressures on the Aitutaki environment, and make the ecosystem more resilient to climate change.

The Church is an important social institution on the island: about half the population belong to the Cook Islands Christian Church; 18% to the Seventh Day Adventist Church; and 7% to the Roman Catholic Church. The remaining 25% of the population is affiliated to other religions or no religion. Sunday observance is adhered to. Women's and youth groups are mainly organized through the churches. The Ariki and Aronga Mana on the island work closely with the churches and the Island Council to uphold island and traditional laws. The World Council of Churches has recognised the importance of climate change and is educating their members on the issue.

Government Support Services

HEALTH

Aitutaki has a 50-bed hospital, following a substantial increase in the number of beds necessitated by the April 2002 outbreak of dengue fever. There is one full time doctor in attendance and one registered senior nurse, both of whom are past retirement age. There is also one health inspector, one public health nurse, three nurse aids, one dentist, a dental technician, and one pharmacist who also works in radiology and the outpatient division. There are 5 child welfare clnics around the island that serve as focal points for mother and child health and immunization activities. The public health nurse and a community grouping of mothers monitor the activities of the Child Welfare Association.

WASTE MANAGEMENT

There is no rubbish disposal program on the island, which makes mosquito and fly control difficult. An ADB loan funded Waste Management Project is designed to overcome these problems through the construction of a landfill, due to commence by 2004. This will require a managed collection and recycling system to be introduced.

Household sanitation is always an issue on islands due to risks of contaminating water tables and lagoons. In 2001, 278 households had flush toilets, 55 had pour flush toilets, and 176 used pit latrines.

WATER SUPPLY

In 2001, 433 households were connected to the public water main, 162 had their own rainwater tank, and 23 relied on public water catchments. The majority (283) had water piped inside the home; 157 had water piped to outside the home; and only one had to cart water to the dwelling.

[10] Aitutaki Strategic action plan first formulated in 2000, attached as Annex

[11] Rongo, T., (1998). Aitutaki resource management policy and proposed resource management by law. Island Friends Cook Islands Ltd.

ELECTRICITY

Over 95 percent of households had electricity in 2001. This was used to run a wide range of household electrical appliances, including freezers (318) refrigerators/freezers (301), washing machines (293), radio/cassettes (389), televisions (412), and video recorders (310). Gas was the principal means of cooking.

COMMUNICATIONS

Standard telephone and fax services are available on Aitutaki, as well as a television service. Access to the Internet can be obtained for 15 cents per minute. There is no Aitutaki newspaper, although copies of the Rarotongan produced daily and weekly papers are flown over from Rarotonga.

TRANSPORT

The island has wharf facilities for off-loading cargo from workboats and barges loaded in turn from inter-island ships near the opening to the Arutanga Landing. The port is presently managed from Rarotonga via the Ports Authority, which has recently purchased a large sand dredging machine with the intention of dredging and expanding deep water access to the wharf. Inter-island ships run regularly to Rarotonga and large cargo ships provide direct access from Auckland and Rarotonga.

50-125cc motor scooters are the predominant vehicle, however the number of cars and trucks being imported is rising. Formerly crushed coral roads are in the process of being sealed around the island and recently additional roads were cut to access sand for the airport extension.

The airport, which has undergone an upgrade and resurfacing complete in late 2003, is fully managed by the Cook Islands Airport Authority from Rarotonga. There are two airstrips of 1.8 km and 1.4 km in length at the northern end of the island. There are at least 3 flights per day between Rarotonga and Aitutaki.

Climate Change & Variability Relevance to Aitutaki, Cook Islands:

General Climate

Aitutaki has a pleasant tropical maritime climate with some variation in the temperatures and rainfall patterns. Like every small island surrounded by ocean, climate is not uniform. A warmer wet season typically occurs from November to April and the cooler dry season runs from May to October. The South Pacific Convergence Zone (SPCZ) and its movement between the Northern and Southern group influences the weather patterns of the island. However, weather patterns are fairly evenly distributed over the 'almost-atoll' due to the low height and small size of the landmass minimising orographic[12] effects. As understanding the current climate variability is key to assessing the potential impacts of future changes, the temperature, precipitation, and extreme events of Aitutaki are addressed in more depth in Appendix 1.

Aitutaki has been fortunate in that it has not been hit directly by a cyclone since Dora in 1967, although Cyclone Sally in 1987 caused extensive damage to agricultural crops. Therefore the potential impact of and response to a direct cyclone hit is beyond the living memory of most residents.

Climate Change Scenarios

Based on models and observations a plausible future for Aitutaki is increasing frequency of extremes such as short intense periods of rain, longer droughts, hotter days, and more storms, as well as rising sea levels aggravating coastal erosion and salt-water intrusion into ground water.

Due to the limitations in monitoring equipment and local capacity, it is necessary to model future climate change based on data available at a larger scale. This 'bigger picture' makes it impossible to pinpoint what might happen to Aitutaki. However, adopting regional scenarios and looking at local trends can tell us areas of concern for climate change in Aitutaki. As the models are fairly complex, their background, methodologies, and scenarios are detailed in Appendix 1.

[redacted]

[12] Orographic effects are the patterns of weather that result from the shape of the land, such as the rain-shadow effect of clouds forming and rain falling on the windward side of a mountain, losing moisture before reaching the other side

RESULTS

1) BASELINES & VULNERABILITY

BASELINES - Defining Problems:

The community consultations were comprehensive in problems they identified as affecting their village at the initial stages of each meeting, many are related both directly and indirectly to climate change.

• Table 1 Summary of Present Problems to be addressed in villages

Sector	General Problems as raised in Village Meeting initial discussion
Water	Water shortage during drought Hygiene issues as a result of water shortage (itchy, soap won't lather (laundry) Water salty, Salt water intrusion to lowland sources Waste Management, Contaminated/poor quality wells, Water quality, germs, bacteria, no purification/treatment/chlorination Insufficient storage tanks Not exploiting rainwater efficiently, storage tanks not hooked up, lack of spouting Rusted water pipes Pressure drop during peak use and drought especially to high ground Wells & other sources dry, too much taken out of ground, Misuse/wastage Improvements in reticulated system placing increased pressure on old pipelines and increasing demand on water galleries
Coast	Cyclone, waves storm surge Marine, Poor reef health, Animals, pigs, being kept beach side, tied to coconut trees Seagrasses – invasive species Fishing (tautai), fewer, overharvesting, breeding areas spoiled, seasonal shifts Coastal wildlife habitat reduction as for land crabs– availability, less Coastal erosion, removal of sand, coastal rock barriers & vegetation, beach loss, sea level rise Erosion of wharf infrastructure Siltation of nearshore port areas, anchorage Impacts of cyclones and storm surge/big waves on reefs and port (limits emergency access) Removal of sand and coral for road construction Coral bleaching due to increasing sea temperatures and other stresses Reclaiming land using volcanic soil Increased turbidity, nutrients, and chemical pollutants associated with soil erosion, agriculture runoff to sea, and human by-products Sewage liquid waste, Agriculture Chemicals overused, residuals from fruit industries affecting coral Damage to reefs from predators (crown of thorns starfish) and human pressures (diving, anchors, fishing)
Health	Ear and eye infections, skin rashes, fungal infections eg ringworm Poor sanitation and food preparation Many breeding areas and high numbers of mosquitoes (namu), some dengue outbreaks, Sand Flies, itchness Diarrhoea outbreaks, water contamination Poor water quality, with negative drinking & bathing effects Stinky seaweed, Maki/Mareti Flu/Colds from dampness and humidity Vacant lands and houses, overgrown vegetation, weeds (tita) Shelter Pollution, air (transport) Temperature changes – colder winters Drought, dust/dirt High level of respiratory problems

Agriculture	Changes in diet, Fruit seasons shifting compared to past eg breadfruit, mango, productivity dropping, Limited water piping to agricultural sites, changing rainfall patterns agriculture hard difficult to plant traditional crops because soil dry, Poor water quality (brackish salty water) Increasing numbers of introduced pests, insects and diseases harming plants Uncontrolled burning Rain destroying vegetables, increasing fungal infections Poor shipments of agricultural necessities (e.g. fertiliser) Poor marketing opportunities for produce Inconsistency of year round supply, shortages of particular crops Pesticide and Fertiliser runoff to streams and lagoon
Tourism & other Development	Land use/problems/ownership Land use changes, Cutting trees, chainsaws Wetland Drainage, Soil/Hillside Erosion from runoff Litter/rubbish, disposal of waste (esp around beach), bottles, large items, no recycling or management Cost of Living – eg hurricane season need to buy lamps, torches, candles, batteries, ropes, etc from the store to increase our ability to cope with hurricanes, not all can afford
Not Directly Climate Related Problems	Change of lifestyle Attitude, people don't care Youth problems Night-clubs, entertainment, school leavers, migration Theft stealing etc

Common issues that are also climate sensitive highlighted and prioritised by villages from the range of problems above were as follows:

- Water, drinking, hygiene, salty, no containers, drought, wells
- Health, diseases, Mosquito (*Namu*) Tita/ vegetation disposal;
- Cyclone, Coastal erosion, beach loss
- Coastal Pollution, pigs tied up, Poor fishing, Coral Bleaching, reefs unhealthy
- Land use problems/ownership, Land drainage, Cutting trees, Soil Erosion
- Food Supply, Agriculture Production/Development, Fruit Season shifts, land crab depletion
- Agriculture/Chemicals Waste, Pollution, transport, air pollution,
- Resources/poverty/costs of responding to extreme climate events

Vulnerabilities statements

Based on the above problems, and the cause & effect exercise carried out in the village meetings, vulnerability statements are organised in sectors of water, agriculture, coast, health, tourism & development, energy and disaster management. While not necessarily described this way by individual community members, these are key areas of peoples livelihoods that are impacted by climate variability and change. This format has been adopted because it is also relevant to government planners and sustainable development objectives that have a key role in reducing future climate change vulnerability. Past, current, and future coping ability for each sector is outlined first, followed by vulnerability statements

Water Coping Capacity:

Overwhelmingly, each of the eight villages raised and prioritised water resources as their number one issue. In terms of prioritisation within the water resource sector, availability of drinking water was of greatest concern, due to the increasing saltiness of the mains water and length of dry periods affecting roof catchment supply. Clearly there is room for improvement in this water resource sector when preparing for climate variability and change, particularly in terms of rainwater harvesting.

As detailed in annexes, most households are connected to the public water mains, of which there is 470 km. The mains draw on water pumped from intake galleries and reservoirs, and suffer pressure losses during drought particularly for houses at higher elevations. These ground water sources become brackish with overuse or salt water intrusion due to their nearness to the ocean, so they are used mainly for non-drinking purposes, including showers,

• Figure 7 Weathered Community Tanks

toilets, dishes and laundry, as well as cooking. There are 43 communal rainwater tanks, but many are in disrepair or landowner issues limit access and maintenance.

The Island Council has noted that a recent Ausaid upgrading of all the reticulated mains system piping as well as improving a number of the community header tanks for the island, although useful, falls short of consumption requirements. The Ausaid project aimed to provide 175 litres per person per day, recognising that might not fulfil demand, and to overcome supply losses of sixty to seventy percent through old rusty pipes. A 1995 in depth analysis of Aitutaki's water resources and infrastructure by Barrett Consulting is attached in Appendix C of Annex 1.

Council has stated major new commercial users will be required to install rainwater collection tanks or desalination systems, and households will be encouraged to install private water tanks, however the mechanism for achieving these goals has not been defined. In addition all households have septic tanks that were supposed to be monitored in order to avoid negative effects of liquid waste on groundwater collection galleries, however it is unclear if this is happening regularly. A high school program, in association with an Oregon sister college, instigated household and community tank water quality testing and found levels of E.coli far exceeding WHO guidelines, however they did not test the water galleries.

• Figure 8 Well on a motu

Water Resource vulnerability:

All natural water resources on Aitutaki stem from precipitation, and any alterations in the patterns or frequency of rainfall will therefore impact on the water availability. Temperature variations can result in changes in plant water use[13], soil moisture, and infiltration rates[14]. Sea-level variations can contribute to varying salt-water intrusion in the groundwater. Also cyclone induced debris, storm surge, and salt spray, can overtop, contaminate, and degrade, the aquifers, wells, and storage facilities.

Precipitation:

It was mentioned that after heavy rainfall the water becomes silty or cloudy, and requires boiling for a couple of days while it settles. Drought is a major concern to the people of Aitutaki with impacts on the drinking water supply in particular. It must be emphasised that the susceptibility of this sec tor to water shortages due to drought conditions is further compounded as a result of poor rainwater catchment and water resource management.

Temperature:

Increased heat does not have a direct effect on water resources. Indirectly heat stress increases human, animal, and plants' evapo-transpiration demand for water. Increased aridity speeds up evaporation of water, which could be a problem if the length of the dry period increases. However the primary effect of temperature is on the Pacific Ocean climate patterns, including the formation of cyclones and a cause of sea level rise through thermal expansion. How these indirect temperature features affect water resources is explored below.

• Figure 9 Manmade cattle pond on Aitutaki

[13] evapo-transpiration
[14] IPCC 1996

Sea Level:

People reported all ground water as being salty and hard. It was not clear if this was due to tidal sea level changes or up-welling of salt water to the gallery intakes caused by overuse. The freshwater floats on top of ocean water due to density differences. At joins within the permeable rock part of the islands there is a zone of mixed fresh and salt water, water at this interface is called brackish.

The brackish area shifts because of the density differences between fresh and salt water. Salt-water intrusion is driven by the weight of the ocean above, and penetrates further inland when there is less fresh water entering the fresh ground water lens, as happens in droughts. With sea level rise the weight of the ocean increases and so does salt water intrusion[15], and the groundwater system is vulnerable.

Extreme events:

The implications of increased ENSO episodes or intensity for water resources are both positive, in that more precipitation may be available for catchment during La Niña, and negative, as more severe droughts like the 1983/84 one can be expected.

For water resources the impacts of cyclones are negative. Although heavy precipitation may fall, usually damage associated with cyclones on water related infrastructure means that this precipitation is not viable for catchment. Furthermore, erosion in the hillside catchment areas is increased, and the transport of high sediment loads and potential pollutants into the catchments and aquifers renders them temporarily unusable.

As suggested by villagers, the most detrimental extreme event for water resources aside from drought is storm surge. These have occurred with dramatic effect in the past, flooding half of Amuri village, after which some abandoned their homes there. These waves can be a result of storms far away creating high-energy waves that travel across the Pacific. On reaching Aitutaki from the open ocean these waves are able to over top the reef and wash well into the porous atoll in seemingly fine conditions. As with waves driven inland by cyclones, water resources in the form of lowland semi-tidal ponds and wells can be inundated with salt water. With the salt on top of the fresh water it can take several weeks for the salt to percolate down to the lower brackish zone, making the resource unusable for crops as well as other purposes.

• Figure 10 Sign indicating the importance of water

Water and Society:

Tap water fed from the community system and stored by individual households and village tanks is used for cooking, washing, and sometimes drinking, but the latter usually only in times of shortage and after boiling. Both rudimentary and sophisticated roof catchments are used for drinking water. Purchasing water tanks is considered too expensive for many individual households, as tanks imported by ship landed at roughly $1 per litre of storage capacity, hence tanks are not standardised, with some people building their own. Most households have poor roof catchment systems because gutters have rusted away or proved too expensive to purchase in the first place. The few with roof catchments were not utilised to full potential, having only one side of the building guttered or using small buckets to act as catchments.

Most people that we met commented on changes in water usage, particularly wastefulness, the need for individuals to take responsibility for their own water storage, as well as the difficulty of

[15] Bronders and Lewis, 1993

embarking on agricultural or commercial endeavours with water limitations. The dependability of the water resources depends on village demand and efficiency of use and conservation. If someone fails to turn the tap off properly on a rainwater tank can be drained rapidly. It also depends on people not over pumping the gallery tanks.

Water resources are also at risk of human activities such as the use and poor disposal of waste and hazardous materials (toxic, flammable, corrosive, reactive, or radioactive). Care needs to be taken with the use of inappropriate water containers such as used petrol or paint cans. Pesticides, herbicides (Paraquat) and fertilisers (fish guts, imported nitro phosphate) used in Agriculture risk contamination of water sources. Placement of septic tanks has caused problems and could continue to do so. Soil quality is directly related to water quality as the soil is the filter for all mains water.

Water Resources Future Climate Change Vulnerability

Taking the best guess IPCC Scenario 1992[a] modified for 1995 with SO2 regionalised, at least 15 cm of sea-level rise and about 0.7ºC increase in temperature over the next 50 years can be expected. This is likely to influence the main areas of water resource vulnerability: precipitation patterns, extreme events, and salt-water intrusion. General expectations based on the scenarios, are for wetter wet seasons, longer dry seasons, some saltwater intrusion due to sea level rise and consequent salinisation of the agricultural water resource, together with greater contamination during potentially more frequent and intense cyclones.

Despite the improvements of the AusAid water project, water resources are currently vulnerable to both climate and human activities. However they need not be if appropriate rainwater harvesting and storage systems are in place and maintained. Groundwater suffers from saltwater intrusion, and there is the potential for this to get worse as sea level rise increases or if the aquifers are over-exploited. The limited capacity galleries installed in the past are not the solution to future water shortages due to the high cost of operating the pumps and expertise needed to maintain them, but form the core of the current water supply.

In sum, water quality is an issue as is water quantity, and while both of these factors are affected by current climate patterns and potential future climate change, the catchment of rainwater from roofs is insufficiently carried out. The National Communication identified four key climate sensitive areas, of these water resources is currently the second most vulnerable to climate change on Aitutaki. However, long-term vulnerability can be reduced because there is potential for full adaptation at minimal cost, provided the recommendations are implemented. This area was the priority issue for the whole Aitutaki community, because they felt that so many other issues such as agriculture and health were related, and because their resilience to water resource shortages in the past had been limited.

Agriculture Coping Capacity

In 2000, only 8 of 444 households surveyed were not engaged in agricultural activity of any sort, although a relatively large number had just a minor involvement (Table 13). Most of the households produced exclusively for home consumption (53%), while some supplemented subsistence production with cash cropping. Nineteen households (4%) engaged in commercial agricultural production, with four households holding bank loans.

52% of the island is suitable for annual and tree crops, and an additional 26% is suitable for tree crops. Vegetable crops include beans, cabbage, capsicum, melons, pineapple, and tomato. Root crops include cassava, kumara, taro wet and dry, and tarua. Wild nono trees are scattered around

• Figure 11 Shrinking taro swamp area that used to be level with trees in foreground

the island and the fruit is collected and exported to Rarotonga. Almost all agriculture practice is situated on the flat plateaux of the island where the richer volcanic soils are found. Little is grown on the sandy edges of the island except some swamp taro species, as in Vainamu and around Tautu. This is a shift from historic times as noted by the Vaipae community.

Mixed cropping is common, typically combinations of tree crops like mangoes, coconuts, and banana with root crops planted in between to fully utilise land area. Mono-cropping is also practised with commercial crops like vegetables, watermelon, pawpaw (papaya), banana and citrus plantations. An organic market garden recently started producing herbs and vegetables for the restaurant and hotel market.

• Figure 12 Tomato Plantation

Export agriculture has been driven more by whim and outside pressure than by sound economic and financial assessment and thus has failed to produce long-term benefits for the island. Banana and Copra production is no longer for export but they are still grown for home consumption. Barriers to re-entering the export market include the crop being prone to hurricane and drought damage, fears of significant fungicide and fertiliser damage to the environment as occurred during the 1980's, shipment and marketing problems and increased costs of labour and fertiliser. Despite ongoing subsidising of the copra industry at the national policy level the farmers felt that it was too much work for too little reward and are unable to compete in volume with other developing countries where labour is cheaper.

The development strategy for the island emphasises other areas of economic development over agriculture, and the agriculture department has been drastically reduced to two personnel. Agricultural potential still lies in the growing of vegetables[16] especially with demand increasing for supplying more tourists visiting the island. Surplus produce is sometimes sent to the Rarotonga market. Arguably, agriculture remains the backbone of the Aitutaki economy for subsistence and the domestic market, while in terms of sustainable economic growth tourism is also heavily dependent on agricultural produce.[17]

Livestock

Of the 444 households, 300 or 68% raised livestock, especially pigs, for subsistence and special occasions. Pig rearing and other livestock like goats and cattle can be seen in the lower edges of the island but more increasingly dominant on the hillsides and the top flat area of the island. There are two commercial production chicken farms raising over four hundred Rhode Island Red breed layers particularly for egg production. Local farmers prefer this breed which is more heat tolerant and hardy to local weather conditions. Also the public likes the brown eggs. Chickens are either culled or sold live to interested locals when egg production drops, usually after three years of production.

• Figure 13Rhode Island Red Layers

The cost of imported chicken feeds required has hindered broiler production over the years, as frozen imported chickens are cheaper. The feral indigenous breed introduced by Polynesians as a source for costume feathers are established around the home area through regular feeding and are captured for consumption. Island chickens are considered tastier although tough.

There is one free-range cattle farm owned by Ron Maki located behind the hill in Amuri. Over 40 head of cattle are being raised for the local retail market. Breeding is achieved through artificial insemination, which

• Figure 14 Free Range Cattle

[16] According to Tiraa Arere (Agriculture Officer).

maintains stock quality and reduces inbreeding in the small local cattle population. The cattle are originally from a part of Australia with similar tropical climatic conditions. Although the cattle fatten well and appear healthy it is doubtful the island could sustain a much larger herd, there have already been complaints about cattle escaping onto other peoples land. The island is nearly self sufficient in beef according to the agriculture officer. Demand from hotels, local retailers and locals, is high.

Horses survive well on Aitutaki and are still sometimes used for ploughing land. However, with the advent of tractors available for rental or free through the Agriculture department, both the use and numbers of horses has declined. People say they miss the horses for sentimental reason, but their future seems to lie in an attempt being made to set up a pony trekking business.

Figure 15 Horses for pony treks

Land Use and Forestry

Changing patterns of land use has affected agriculture over the years with agricultural lands making way for housing and tourism accommodation. The change from traditional subsistence farming and agro-forestry to increased use of imported products will probably continue, reducing self sufficiency, and creating a economic imbalance of imports over exports. Much concern was expressed in community meetings about the effects of a shift away from fresh fruit and vegetables in the diet of children. Land use changes have caused widespread depletion of the forest resource. Hence the cutting of trees, was a frequently noted issue in the community consultations, with many believing this has contributed to reduced ground water.

Some farmers are using a different method of growing vegetables, hydroponics, which is totally reliant on nutrient loaded water circulation as the feeding mechanism that gives out all what is needed for plants to grow. According to farmers, difficulties maintaining water quality for the hydroponics affects productivity and cost. Water feeding the system coming from the public taps is frequently too salty or too alkaline for the crops to grow in. Rainwater collected in storage tanks is also fed to hydroponics as a stand by, but salt spray that accumulates on roofing runs into the catchment and also ends up in the system. A water quality-monitoring meter to maintain optimum growth proves a useful piece of equipment even though it is extremely costly for the individual.

Figure 16 Hydroponics Water Quality Monitor

Most of the inland natural forest land has been converted to farmland where the volcanic soil is fertile. The ability to clear the land by bulldozers, tractors and other heavy machinery is an additional problem to the traditional use of fire for clearing. Fern and bush land easily catches fire when the burning processes are not managed properly, leading to the loss of valuable trees. The lack of replanting and wandering animals (pigs and goats) that tend to eat young shoots means regeneration of trees fails and invasive weeds tend to take over the degraded soils. A vast area of grassland stretches on the hills to the north-west side of the island especially around Amuri area. There are a large number of introduced plant species and a number have become a problem because of their invasive nature. Wildlife species are limited including geckos, skinks, coconut and hermit crabs. Wild and domestic cats threaten the bird life but there are no dogs on Aitutaki. Mosquitoes and sand flies are both introduced problem species and are proving difficult to control.

Agriculture Vulnerability

The potential vulnerability of Aitutaki agriculture to climate variability and climate change has become an issue many more people on the island are aware of. The

V&A Research Officers provided some general information to a growers meeting in 1999 regarding present and future vulnerability of agriculture to climate change. Opinions reflected that some of the potential impacts particularly related to temperature related changes in growing are already happening. If this is the case farmers may respond early and be prepared, as vegetation patterns on the island may shift irreversibly over a longer period of time.

Rainfall

The most important climatic factor influencing agricultural practices, changes in rainfall patterns can cause serious crop failure or reduced crop yields, and could affect crop cycling and predictability of appropriate planting times. Increases in lack of rain during the dry season would require expensive irrigation and water storage to maintain productivity. People complained dry soil is difficult to plant. Evidence of a dropping water table was apparent, with former taro swamps shrinking In addition, some lower areas become boggy with excessive long-term rain, from the sediment blocking drainage, which may contribute to rotting of crops that are now being selected for drought tolerance. However, a positive aspect may be altered rainfall patterns possibly increasing growing seasons or suitability of certain crops while others suffer.

Temperature

Amongst others vegetable crops are especially prone to wilting in high temperatures, and yields of certain root crops like taro and tarua are affected by temperature. Some of these effects on productivity may be offset by faster growth rates with warmer temperatures and more carbon dioxide in the atmosphere. With temperature changes the availability of fresh water and the distribution of pest and diseases may also have significant impacts on agriculture production. Already aphids (patapata) on taro have affected yields in areas such as Vainamu. Not all taro groups would be equally affected as puraka and tarua are already more resilient to pests

Sea Level

There is a potential threat from sea level rise as productive land near the coast could be lost through erosion or the ground water beneath could become too saline for crops. Storm surges are likely to penetrate further inland with higher sea levels and salt spray continues to threaten sensitive crops especially the eastern side of the island as it is more exposed to strong winds.

Extreme Events

As a consequence of climate change more extremes are expected. Cyclone Sally in 1987 was the final blow to the ailing banana industry, indicating potential devastating effects on agriculture if such events become more frequent or intense. Intensification of El Niño events is a key concern that could devastate crops and also lead to livestock starvation particularly for the horses, cattle, and goats from lack of pasture to graze. Intense heavy rain is an equal concern when it causes flooding leading to rotting of root crops, rapid soil erosion, leaching of nutrients and agricultural chemicals, increased fungal diseases and population increases in certain pests such as caterpillars that multiply more in wet conditions.

Coastal Coping Capacity

• Figure 17 Typical Low Lying Hotel Location on Motu

The coastal area is where most people and infrastructure are situated, in addition to vital marine and terrestrial species habitats like the reef system, coastal vegetation and bird nesting areas. In Aitutaki this area is the most economically and ecologically important to the people, providing food for families and the major tourism attraction, while being most at risk of coastal instability, cyclones, sea-level fluctuations, reef

degradation or changes in sediment supply[18]. Many people reside on a low marine terrace along the western shore, near the Arutanga harbour facilities on the coast, which has been exposed to storm surge flooding in the past. Tourism facilities, rapidly increasing in number, are almost all on low ground near shorelines, while the airport and Marine Resources station are on the north-east motu terrace.

Siltation and sediment run off from past agriculture practices results in the lagoon being murky in some areas. Because Aitutaki has volcanic soils when they get deposited in the lagoon light penetration that favours coral growth is reduced. Similarly, sand mining from the foreshore of the lagoon is causing environmental disturbance. As one community member said volcanic soils and sand do not mix well. Sands are used for the construction of the road and island decision-makers have stated this will continue until all the roads on the island are fully sealed[19]. Communities said the eastern edge including the Ootu peninsula near the Akitua and some motu have been experiencing coastal erosion. Wild stocks of clams in the lagoon may have been affected by altered sediment flows, with many dying and numbers declining, especially around the deeper parts of the lagoon[20].

Coastal Vulnerability

Sea level rise, changes in storm intensity and frequency, temperature, precipitation, and storm surges are components of climate change that will potentially have a great impact on coastal areas over the coming years. This could be devastating for Aitutaki, as all of its population is dependent on coastal areas in one way or another. Many Aitutaki houses are situated behind a buffer zone 20-30 metres inland, however as a result of not having EIA's most areas are increasingly at risk, particularly the new waterfront tourist establishments. Rising sea level could inundate low-lying areas, erode shores and increase salt-water intrusion into ground water supplies to which much of Aitutaki is already vulnerable.

Although it is not likely that Aitutaki would disappear under sea even with the highest projected rates of sea level rise, the effectiveness of the reefs in protecting coasts and motu might be affected. Coral reefs provide natural breakwaters for coastlines and will become increasingly important for storm and erosion protection. Due to the relationships of coral reefs to light, temperature and sea level, corals and reefs have long been regarded as vulnerable to climate change and are reliable indicators of past climates and sea levels. Coral animals are very sensitive to temperature, living with a narrow depth range where the temperature is between 24°C – 28°C. Slight changes of 2-3 degrees higher or lower for two to three days cause coral to eject their food supplying colourful algae (zooxanthellae) resulting in bleaching or whitening[21]. In Aitutaki, there has been mass bleaching of coral associated with El Niño disturbances[22] in 1994.

The question remains whether reefs will keep up, catch up, or give up, with sea level rise and climate change, and this is related to how healthy the reefs are presently. Poor reef health is usually a result of human by-products and activities, and in Aitutaki the ecosystem that supports coral reefs has already been stressed by past agricultural run-off, sedimentation and El Niño events.

Fisheries

Like agriculture, fishing has always been part of the livelihood for people in Aitutaki, who depend extensively upon fish in their daily food supply. Even though there has been a shift to tinned products throughout the Cook Islands, fishing is still a common activity as restaurant demand is increasing and most families regard it highly for feeding their families, recreation,

[18] Forbes, D (1995) reports sediment supply can change with sand extraction, harbour dredging, or other artificial manipulation of the reef flat, lagoon and shore zone.
[19] According to the Mayor Teokotai Herman, 2000.
[20] According to Marine Resources Officers and some interveiwees
[21] Greenpeace: Climate time bomb; signs of climate change from the Greenpeace database, 1994.
[22] A study was done in 1994, showing 90% bleaching.

and a source of income. In 2000, 285 households were involved in fishing, 211 of them solely for home consumption and 67 for subsistence and occasional sale. There were 7 households engaged in commercial fishing. The average number of fishing trips per month was 4.5, involving mostly hook and line fishing, gillnetting, and spear fishing in the lagoon or over the reef. A distinguishing feature of fishing in Aitutaki is that 54% of the households engaged in fishing used an aluminium or home built motorized boat. Surplus fish caught are stocked in freezers for future supply or sold locally or to the Rarotonga market for cash.

The lagoon is rich with of wide range of marine resources, a discussion of key harvested species such as fish, seaweed, and invertebrate slugs & shells, along with the bonefish market, and ra'ui system is annexed. In response to community concerns that fish and other marine populations have been over-harvested and poorly managed, marine harvesting is prohibited in four ra'ui areas declared by the Aitutaki Aronga Mana (traditional leaders) and Island Council to allow marine and terrestrial ecosystems within these areas to recover. The ra'ui areas introduced in 2000 cover 12% of the Aitutaki lagoon and are located at sites in Oótu, Motikitiu, Maina lagoon, and Maina reef.

• Figure 18 Map of the marine conservation areas

Fisheries Vulnerability

While many community members identified fewer marine resources as an issue, it was more difficult for them to indicate causes, possibly because of the complex role of factors like temperature, precipitation, sea level, and extreme events, described below, as well as the noted aspects like the use of modern equipment including outboard engines and too small gillnets.

Temperature

Though little has been documented from the local perspective, anticipated changes in sea surface temperatures would lead to global changes in wind and ocean circulation patterns. The distribution and availability of nutrients for local migratory and non-migratory fish stocks are dependent on these patterns. When the pelagic fish such as tuna and wahoo migrate by Aitutaki was once understood by fishermen based on the time of the year and the temperature of the water, however the traditional knowledge is becoming less valid as the oceanic climate shifts. In addition, phytoplankton (sea plant) production could also be affected by sea surface temperatures and result in disruption of the deep sea fish food chain. Warming seas would result in coral bleaching as seen in past El Niño events. Such stressed reef habitats provide opportunities for ciguatera dinoflagellate organisms to colonise the coral surfaces making the reef fish that feed on it poisonous for people.

Rainfall

The lagoon has already experienced sedimentation accumulation from past agriculture run off which threaten native clams and corals. Freshwater runoff flowing to the sea alters water salinity and brings nutrients that excessively increase algae production. Salinity within the lagoon affects life in the ecosystem, so if precipitation patterns fluctuate then the lagoon could in turn be too salty or too brackish for the animals that are living in it.

Sea Level Rise

With climate change, fish habitats (coral reefs, sea grasses) may be affected especially by Coastal erosion and more frequent storm surges.

Extreme Events

The recent cyclone that hit Niue demonstrated the extent of damage big waves can do underwater to reefs, resulting in the concern that there may not be enough coral left to sustain the fish that are so important to their diving and livelihood. Cyclones can severely damage infrastructure associated with fishing including the ports and nurseries. Storms are also a major threat to the safety of fishermen.

Health Coping Capacity

Tables in Appendix present the key health indicators for Aitutaki. Influenza and acute respiratory infection are problems requiring the maintenance of basic pharmaceutical supplies. Diarrhoea, conjunctivitis, fish poisoning and asthma cases are also of concern and draw attention to the importance of diet and sound environmental conditions. Any health intervention must be mindful of hygiene, food safety, and safe water supply. Rising incidences of non-communicable diseases have been noted in recent times, suggesting a focus on long-term preventative public health measures.

The Aitutaki hospital provides in-patient and outpatient care similar to Rarotonga's nominal fee 'user pay' system. Although there is an improvement of health standard in recent years most locals find the introduced 'user pay' system a burden. The hospital is located on the hill in Takapora close to the most populated area. It is an ideal site for exposure to prevailing trade winds supplying ventilation needed for patient comfort particularly in the tropical climate without feasible air-conditioning.

There is a dentist on the island but lack of dental equipment is a problem, whereby only cleaning, extractions, and fillings can be done. An optometrist comes once every eighteen months as part of the island health services. Patients with serious illnesses or complications are either sent to Rarotonga or New Zealand for further treatment. Referral cases usually average 2-3 per month, however the number increases in the event of emergencies or accidents.

Vector borne diseases are those that do not directly infect the victim but require a host to transfer them from one person to another. Vectors include flies, mosquitoes, fleas etc, which pick up a microscopic organism or bacteria from one animal or place and carry it to another. Mosquito carried diseases such as dengue fever and filariasis have been common in Aitutaki, problems have been minimised due to biannual community health inspections (Tutaka), public awareness, media, and efforts from individuals, along with prompt responses from health services when outbreaks loom.

Water related diseases are not a frequent problem according to an island doctor, but poor hygiene, sanitation, and unsanitary food preparation practices are a major health concern. Outdoors eating habits mean food scraps dropped near households become favourable breeding areas for vectors like flies and bacteria. In addition, food is often exposed for long periods to variable temperatures and flies prior to meals. Food poisoning related cases like stomachaches and diarrhoea among visitors and locals alike are common after eating island food at umukai (feasts) or at local restaurants and hotels.

Ciguatera poisoning has become a problem from eating reef fish that eat algae, which contain small animals (dinoflagellates) that in large doses are toxic to human nerves. Ciguatera is rarely fatal but produces unpleasant and long lasting digestive and neurological symptoms that can result in severe dehydration and toxic shock. Ciguatoxins are more common in warmer waters associated with disturbed reefs

Health Vulnerability

There is growing concern about the adverse effects of climate change on human health in remote islands such as Aitutaki, due to potential changes in disease vectors such as mosquitoes, water-quality, and the ability to respond to climate related ills like heat stress, seasonal influenza and respiratory infections. The Intergovernmental Panel of Climate Change (IPCC) has indicated that these effects will be diverse and both direct and indirect.

Studies have noted the correlation between temperature rises and specific health impacts like heat stroke and exhaustion, as well as reduced work rates and productivity. With changing weather patterns and extremes being more favourable for some insect populations, vectors are

expected to increase,[23]. Therefore a potential effect of climate change is that some of these tropical diseases[24] like dengue fever, filariasis, yaws- a kind of skin infection, and tuberculosis, will re-emerge.

For example, the El Niño phenomenon has raised awareness of the potential effect of extreme weather variability on health and diseases transmissions[25]. El Niño has been linked to cyclic outbreaks of dengue fever,[26] malaria,[27] cholera[28] and other emerging infectious diseases[29]. Controlling infections could also become difficult due to increasing antibiotic, drug, and insecticide resistance that decreases effectiveness of control methods.

Furthermore, the alteration of some crops by climate extremes will probably cause disruption in the diet of those that rely on agriculture products as part of the food supply. Increased dependence on imported goods will make it difficult to reduce current high levels of obesity, gout, and other lifestyle diseases. Vulnerability especially to extreme events is greater in the portion of the population that is disabled or requiring special medication. In evacuations the limited mobility of the infirm and potential interruptions of supplies of items like insulin for diabetics and makes people more vulnerable.

Tourism Coping Capacity

Tourism was not listed as a climate related priority sector by the community directly, however there were many references to tourism in the cause and effect group exercises. Numbers are expected to increase as accommodation capacity increases with events such as the opening of the Aitutaki Pacific Resort in October 2002, leading to some concerns about the coping capacity of the island and infrastructure.

Tourism is the leading sector for Aitutaki's development, which contributes substantially to the local economy. Tourism has improved quite dramatically with Air Rarotonga's multiple daily flights and larger plane to and from the island. The 45-minute hop is in high demand as a result of improvements in daily activities, day tour packages, and accommodation facilities. The island hosts approximately 12,500 visitors per year who now stay up to 4 days, and about 4,200 daytrippers per year. Most are attracted to the wonderful setting and the peaceful nature of the island, white sandy beaches, elegant blue lagoon, and idyllic trips to motu within the reef that are unique from other nearby outer islands attractions.

Tourism-related businesses include 6 restaurants, 9 tour operators offering lagoon cruises and/or diving, four fishing tour operators, three guest houses in addition to those listed in Table 15,and two Internet cafes. A few women are producing handicrafts for sale to tourists. Tourist infrastructure, including the newly upgraded and extended airport is located around the coast on the main island and at Akitua motu. Accommodation ranges from resort hotel accommodation units to several low-budget and local guesthouses that provide family hospitality. Table 15 in Appendix lists accommodation currently available on Aitutaki.

Tourism Vulnerability

If climate changes as predicted, visitors might not be assured of their comfort or that the natural environment will retain its attraction. Infrastructure and water resources may not be able to cope. The perceived remoteness of the destination would become a reality in terms of vulnerability to climate change. Access to the island by air or sea during extreme weather events is difficult. The airport is in a very exposed coastal strip and flights are cancelled in bad weather, so it would be difficult to get tourists off the island by air.

---

[23] Dr. Aung, Personal Communication 2000.
[24] Nicholls, 1993; Lewis et al, 1998; Easton, 1997.
[25] WHO, 1996; Patz et al, 1996.
[26] Hales et al, 1996.
[27] Bouma et al 1996; 1997.
[28] Colwell, 1996.
[29] Hales et al, 1998.

Accommodation establishments are not set up to deal with long-term water shortages or floods. Most tourist activities on the island are focused on exploring its natural features, which can be difficult in inclement weather that may become more frequent under the climate change scenarios. Travelling to the islets by small passenger boats is particularly uncomfortable in rough weather.

Health wise, tourists are generally more sensitive to biological water and food contaminants than locals, whom have often built up resistance to bugs that breakout in certain climate conditions. Mosquitoes and sand-flies are a nuisance that become more prevalent in climate extremes such as drought followed by floods, or extended wet seasons as during enhanced La Niña events. Additionally mosquito carried diseases such as dengue, and ciguatera fish poisoning aggravated by climate shifts, are hazards that tourists need to be made aware of. Similarly the number of dangerous marine animals such as stone-fish may be linked to local and regional climate variations.

These are important considerations for the tourism industry, which require some response as tourists frequently hold countries responsible for negative experiences, and insurance companies are not forthcoming with compensation needed in the face of increased climate variability causing damage to tourism infrastructure. The impact of publicity about climate extremes, such as floods or cyclones, and disease outbreaks is known to negatively affect tourism to destinations in the same way as publicity about political unrest

Energy Coping Capacity

Electricity is generated by 3 Lister diesel generators with a capacity of 3000kw hours, operating 24 hours at 42 kw per hour. Power is supplied at a cost of 42 cents per Kwh for domestic use and 60 cents per Kwh for business use, except major users such as Pacific Resort pay concessional rates of 44 cents for the first 50,000 Kwh and 40 cents thereafter. There has been significant growth in total electricity generated each year as tourism growth and the increased use of household electrical appliances has more than offset population decline.

The Ministry of Works (MOW) is still responsible for operating, maintaining, and financing the power station on the island. A few households and a large number of tourist accommodations have photovoltaic (solar) energy used for heating water only. At present a large number of people and households have not been able or willing to fully exploit renewable energy sources like solar or wind power.

Energy Vulnerability

Warming due to climate change will most likely increase energy consumption of refrigerators, fans, and in some cases air-conditioning for Aitutaki households. However energy efficient appliances are improving all the time and may reduce the rate of energy used, provided these appliances are preferentially imported to Aitutaki and there is public awareness and incentives for their use. Vulnerability of the energy system arises from the dependency on transport and shipping of the diesel as well as limited storage capacity on the island. In adverse weather conditions shipping and unloading is difficult, and if extreme events increase as anticipated could result in longer intervals between fuel deliveries. Also live wires that are blown down in high winds or washed out from underground by storm surge are a hazard following extreme events.

Baselines and Vulnerability Summary

The wealth of information available and needed for a full V&A assessment would form a much longer thesis than this document and could not be achieved in the short consultations the assessment team undertook in Aitutaki. Instead it is hoped that the data provided herein provides the reader with a general picture of Aitutaki as it is now and development directions for near future. In addition to the physical and socio-economic description, a decision-maker

oriented sectoral approach has highlighted climate risks for the areas of water resources, agriculture, coasts, health, energy and tourism.

An interesting point is that community members identified all these problems, causes and effects based purely on their own experiences and observations and with little reference to climate change per se.

Communities will need to take ownership of issues and response actions and this will require them finding a balance between economic development and preservation of natural resources for the future, taking into consideration climate variability and change. Initial assessment of the infrastructure capacity and some socio-economic projections of future conditions has been undertaken and reported on by consultants for the Office of the Prime Minister. However in the five years since the final report of the Aitutaki Infrastructure evaluation, tourism has grown faster than predicted, although the island population has shown less growth, which means some re-evaluation and verification is called for.30

This report section has shown that nearly all sectors are sensitive to climate in the present and despite the Aitutakians' ability to cope with their current exposure levels, they are vulnerable to future climate change unless measures are taken to increase resilience. It is hoped that feedback on this report and a consultative or workshop approach similar to that undertaken by the Rarotonga based Country Team may serve to expand on this understanding of Aitutaki's risk in relation to future climate change.

[30] Barrett Consulting Group (1995)

3) ADAPTATION ASSESSMENT AND OPTIONS

Adaptation Experience

While adaptation to climate change may be a new necessary consideration to the decision-makers of today, their Aitutaki ancestors have used many approaches to cope with both climate variability and change in an isolated and exposed location. It is important that methods that increased resilience, particularly to extreme events like drought, cyclone, and storm surge, in the past are observed and promoted in the present where appropriate. Nevertheless, lifestyles and goals of the Aitutaki people have changed over time, so traditional knowledge can be difficult to resurrect and apply, and new response strategies must also be found.

The community consultation meetings allocated time to 'solution finding' for the problems that had been prioritised in each village. These are presented in textual form below and listed in table form at the end of this section. Opportunities for adjusting to climate change vary in scale, however the basic level of doing a little at a time to manage and protect the Aitutaki lifestyle with community involvement is likely to reduce risks.

Water Resources Adaptations

As the priority problem identified in the community consultations overwhelmingly focused on water resources, more time was devoted to identifying solutions for this sector.

Aitutaki is one of the few places where hydrological surveys to understand the ground water potential have been carried out[31]. Up-welling and saltwater intrusion are the biggest issues for the galleries that feed the water mains system. Village demand is projected to increase from population concentration and the introduction of more water demanding modern conveniences such as washing machines.

Now that AusAid has completed an upgrade of the reticulated water system, improved rainwater catchment systems are the most obvious adaptation. Water available through seasonal rainfall can be sufficient to supply the needs of the population, particularly as precipitation is expected to increase in the Southern Group under most climate change scenarios. Rainwater is the most cost effective and cleanest source of water for the people in these villages, yet there remains great potential for its capture, storage and use, based on estimates that only 10 to 30% of the rainwater potential is being captured from the iron roofs. Apparently time, funding, cyclones and lack of storage capacity have set back government and village initiatives in installing and maintaining this infrastructure. There needs to be incentives for maintaining guttering and pipes to tanks.

Regular drinking water testing is recommended to determine quality issues. Water treatment ranges from boiling through to chemicals. Because the gallery fed water is often quite brackish and hard, many people in Aitutaki consistently boil their water, especially for babies. This is a low cost adaptation that needs to be encouraged, relative to the high cost of chemical treatment at the source. In house filtration systems that remove giardia and other health harming microorganisms are available in the Cook Islands, but at between NZ$300-$600 each they are unlikely to become widely used.

Already there is a need for control of public water resources in the form of meters and rationing when needed because of the cost of running the pump and the potential exhaustion of the header tank. At an agricultural meeting the mamas complained because on the one hand they were being asked not to water their gardens during water shortages, while at the same time the FAO was trying to promote backyard agriculture. User pays or penalties for excessive use could be necessary if more commercial enterprises were established in the future using a disparate amount of water compared to the general public. The Island Government

[31] AUSAID water project

encourages people to store and conserve their own water, and perhaps could enforce a by-law requiring the tourist accommodations and other small businesses to install rainwater tanks.

Given that the bank based in Aitutaki is unable to give out loans for personal or household use, a revolving fund could be developed. Money loaned to a few households to purchase rainwater tanks and spouting (currently prohibitively expensive at roughly $1 per litre storage) once repaid would then be loaned to other households for similar equipment purchase. Community tanks face the problem of no-one being willing to maintain them, however people tend to be more vigilant about personal resources.

At the same time villagers could ensure that when new pipes are laid they suit the environment (rust proof) and are standardised for ease of maintenance and efficiency. Underground piping shields the connections from the worst wind forces, although breaks are harder to monitor, and the introduction of the new reticulated mains system with increased pressure has blown many of the aging household connections actually increasing water leakage, so a household level initiative is required to reduce water loss..

Further adaptation options to explore include, using brackish or seawater for appropriate systems, and cleaner toilet systems, for example the compost toilet, which might reduce contamination as well as having positive spin-offs for agriculture. Finally it is advisable to have disaster relief supplies ready and a strategy for their import as has been achieved in recent emergencies for other Cook Islands.

Coastal Area Adaptations

To deal with current and long-term coastal problems the locals and Aitutaki Island Government could adopt their draft environmental by-laws for part of an integrated coastal zone management (ICZM) approach. This involves the assessment, setting of objectives, planning and management of coastal systems and resources, while taking into account traditional, cultural and historical perspectives and conflicting interests and uses. These practices may be regarded as "no regrets" adaptation strategies, which will have positive outcomes even without climate change. The Aronga Mana[32] would be instrumental in encouraging the other villagers to adopt appropriate strategies such as those suggested below.

Coral reefs provide a range of ecosystem services that increase the resilience[33] of the coastal system, hence adaptation options to protect reefs could be the best way to cope with impacts. Protecting the coastal vegetation from further clearing could reduce the impact of storm surges, wind damage and reduce terrestrial runoff. Allowing the coastal trees to regenerate around the wharf area may absorb some erosion impacts of cyclones and sea surges. This would be a better option than fixed concrete or rock sea walls that tend to get undermined quickly and cause other problems. Setting an environment law in place for any development activities such as sand mining and land clearing at certain boundaries would reduce further damage of ecosystems within this area.

Relocation of villages further inland is an unlikely option despite this having happened in the past. Tourism and tradition favour the coastal forefront, in addition modern land tenure systems would complicate any relocation. Alternatively, any new buildings can be encouraged to accommodate the climate problems through sturdy or traditional construction (no concrete blocks replacing nails to prevent corrugated iron roofs from blowing away under normal conditions!), and maximisation of natural cooling through the prevailing winds, roof catchments and water storage. Architects, electricians and plumbers are almost all sourced from Rarotonga so would have considerable influence in the ability to adapt to climate change.

The least expensive and disruptive adaptation options will prevail. Thus the setting up of bush, foreshore and marine protected areas could benefit the whole island's biodiversity and

[32] Traditional Leaders

[33] ability to resist and recover from storm surge, erosion, and other climate variability and change impacts

development at minimal cost. Involvement of interested non-government organisations, government, and institutions can help foster community response to their problems and educate them about the threat of climate change.

Health Adaptations

There are a number of measures that would improve the ability of Aitutaki to adapt or respond to climate-induced changes to human health. These require continued investment in public health infrastructure. Advanced weather warning systems, improved disease surveillance and prevention programs, building codes[34] to prevent storm damage, enhanced sanitation systems, drinking water safeguards, pollution controls and health education all need to be looked at in terms of climate change.

Already public awareness on certain diseases like dengue fever has been excellent. Further public awareness activities on potential re-emerging diseases such as tuberculosis and filariasis could provide an incentive to adapt. Continued household health inspections (tutaka) twice a year help to clean and control mosquito-breeding areas. Full elimination of vector populations is unlikely, but controlling them at certain level could become the ultimate goal for the people of Aitutaki.

Moreover, convincing a change in people's attitudes to health care, focusing on prevention rather than cure, reducing assistance required from the health care system, the government or abroad is important. Internet assisted diagnosis has recently been introduced in Aitutaki[35] and is proving useful in reducing costly referrals to overseas specialists. Improving public understanding of the potential impacts and responses relating to human health in the islands in order to plan and adapt to future climate variability and change impacts should be achieved indirectly by supporting and incorporating material on health awareness in school and community gatherings.

Agriculture Adaptations

Adaptation options may include changes in crops and their varieties, development of varieties, timing of planting (schedules). Irrigation to most agricultural sites is poorly maintained so improving water management and irrigation systems in the island reduces cost and vulnerability in long run. In addition there is a need to revitalise the use of traditional knowledge and practices which much of the younger generation need to understand, and to continue practices such as crop rotation and fallow period.

Adaptive Management practices might involve composting, hydroponics, irrigation and drainage techniques. The push by the Cook Islands Organic Growers Association emphasises application of biological controls as well as new gentler and species-specific fertilisers, pesticides, and herbicides. Workshops in these integrated pest management areas may motivate Cook Islanders to attempt growing in difficult conditions. Such help in establishing sustainable agriculture was requested within a meeting of the Aitutaki Women's Association. New agriculture methods, including the tissue culturing introduced in Rarotonga combined with traditional agricultural breeding methods, could prove effective in altering plants to adapt to diseases, pests and to better withstand environmental stresses, such as drought.

In response to climate change, where any arable land may be placed under increasing heat and drought stress, understanding and altering planting dates may help take advantage of shifting rainfall patterns and improve crop success. Some of the plants may in fact grow faster, due to higher carbon dioxide concentrations in the atmosphere, but this would aggravate water shortages through evapo-transpiration. The Meteorological Service could be of assistance to growers with weather predictions and information distribution. Currently Aitutaki receives very little user-friendly island specific feedback from the automatic weather reading station data.

---

[34] There is a Building Regulations and Standards Act 1991 that applies nationally

[35] Cook Islands News Article, 2000

Relocation of some crops may be required to avoid sea level rise and salt-water intrusion impacts on soil viability.

A most important adaptation would be improvement of food storage. Disaster management favours stocking of long lasting foodstuffs at all times. After cyclones and in the early stages of crop failure these supplies would be valuable sources of food. When the people hear a cyclone is coming on the radio, they can go out and chop the foliage off the cassava plants which enables them to recover quicker post-cyclone. Processing of locally available food products like dried fish, dried bananas, or cassava and breadfruit chips could help supplement the diet in emergencies.

As Aitutaki is an official Cook Islands Port of Entry, restricting importation of cultivars and quarantine is one step that has already been taken intermittently, but maintaining control is important to reduce pest infestation given increasingly favourable climate conditions. This may conflict with the adaptive strategy of diversifying crops, as well as importing externally-bred heat, salt, and wind tolerant species. This issue was discussed in a meeting with the Growers Association and the FAO representatives. However, with careful research and management both diversification and maintenance of biodiversity could be achieved.

Further adaptive options include ongoing co-operation in the Natural Heritage Project and agriculture in Rarotonga to preserve the formerly diverse and popular varieties of crops, like bananas, in case they fall prey to pest and diseases, and diversification, providing farmers with the opportunity to explore other crops. Since local farmers understand the local conditions and are accustomed to cultivation in those conditions, crops which have been traditionally grown for subsistence are sometimes more easily adapted for cash cropping than introduced non-traditional and climate sensitive crops.

The people of Aitutaki must initiate action together with the help of regional organisations like FAO to find and market such crops, while also ensuring sustainability of ventures in the face of climate change. It is also important to improve knowledge and access of local communities' to development, production and economic benefits of new cash crops such as Nono[36]. Timely and continuous release of information and payments to growers is important, bearing in mind these will have to respond and adapt to the impacts of climate change.

Energy Adaptations

Aitutaki has the only profitable energy department of the outer islands. There is an agreement with the large Pearl Beach Resort that subsidises user fees. This means the generator is not running inefficiently below capacity in the off peak hours. The underground cables and grid protect the power supply system from high winds, an adaptation highly suited to cyclone prone Pacific Islands.

A level of self-sufficiency is found in the personal generators, solar cells, and wind units found in certain households. This is an adaptation that needs to be expanded to overcome the primary vulnerabilities of the energy sector, dependence on and cost of fuel shipments along with limited fuel storage capacity. It would be desirable to cut damage to equipment from power fluctuations.

Voluntary measures by the public in improving fuel use may improve the sustainability of 24-hour power without excessive peaks and as demand increases. This could take the form of replacing incandescent bulbs with compact fluorescent light (CFL) bulbs. A similar project instigated by Tom Wichman (GHG Consultant) on Mitiaro island was highly successful in reducing energy consumption by nearly 80%. The bulbs are more expensive initially, but have a longer life span and pay for themselves within two months of energy savings. With commercial enterprises potentially increasing energy demand on the island it might be possible

[36] A medicinal plant that is exported for the holistic health market

to include them in an information campaign reminding people to turn of appliances not in use and minimise energy and water usage.

Encouragement through policy is needed to import only energy efficient products that meet a particular standard. Appliances such as refrigerators are not necessarily suitable to the tropical conditions, because of poor insulation in high ambient temperatures. Few people have water-heating systems, and those who do generally have solar panels, unfortunately tax exemptions are no longer available for thes e more environmental friendly options.

Alternative Energy Potential

Due to its location in the south-easterly trade wind belt and its high relief, Aitutaki could make an ideal location to trial wind power supplements to traditional diesel driven generators. Plans are underway for a public community, Danish Government and Commission for Asia Pacific (ESCAP) project to be implemented in the Southern Cook Islands starting with Rarotonga and Mangaia, and if this project is successful it may be possible to expand other islands.

Solar energy or photovoltaics are in use on other islands in the Cooks. At this point Aitutaki does not seem to have investigated the full potential of this energy source. It may also be possible to have a hybrid system, linking diesel, wind, and solar power. Hybrid systems have increased potential efficiency with fuel cell technology. There is also the option of using solar for specific equipment such as an icemaker, desalinisation unit, or freezer. This could be especially beneficial installed at the wharf for the fishing people, keeping their product fresh and increasing export potential.

Disaster Management

There is a disaster management plan in place that clarifies the roles of the mayor, government ministries and agencies. The relatively large population would need time to get to ten evacuation centres on higher ground and this requires co-ordination. Currently Aitutaki is vulnerable to any natural disaster as telecommunications failure in extreme events is a potential problem, so contact with the emergency operations centre in Rarotonga is to be maintained by radio. Similarly the power supply to essential services needs to be maintained by OMIA, and the Red Cross is responsible for distributing available supplies if necessary.

Tourism Adaptations

More local self-sufficiency in this sector is desirable and would spread the income from tourism further in the community. Using local building materials including thatched roofing can help the island economy and reduce replacement costs in the case of extreme events. The business owners can ensure that their clientele are not placing a burden on the island's resources by increasing their water catchment and storage, using alternative energy sources, and educating tourists about the unique aspects of Aitutaki, as well as its problems.

In particular, tourists need to be made aware of potential health hazards from drinking non-purified water, eating ciguatoxic fish, the rapid multiplication of bacteria in hot and humid climates, along with exposure to mosquitoes and sand flies. At the same time this must not be overly negative awareness raising, information should also be given on appropriate responses to these afflictions, and the ready accessibility of health services available to visitors. Most problems tourists may encounter as a result of climate variability and change are preventable provided they are either given instruction or protected by their hosts.

Tourism Cook Islands with the help of the Cook Islands Meteorological Service already makes available general climate data to prospective visitors. Ongoing and up to date information on the most suitable times of year for tourists to visit is important, and clever marketing can draw different types of visitors who may be more tolerant of varied climate conditions to ensure tourism is not so seasonal. For example wind-surfers and surfers appreciate high seas and

winds, while eco-tourists may tolerate some rain if it enhances their nature and wildlife experiences. It may be advisable for the island accommodators to close and take their annual holidays during the warmest most humid months. Global warming could excessively increase human discomfort and demands on island infrastructure, such as the power supply to run air conditioners.

General Adaptive Strategies

There is an ongoing need for valid and relevant data collection to ensure that observable changes in climate are detected. Part of this would require on-going automatic weather station maintenance. The Meteorological Service lacks the funds for regular travel and inspections, so perhaps a local individual could be trained. Schools could also get involved through programs such as Schools of the Pacific Rainfall Climate Experiment (SPaRCE), as well as through social science projects that emphasise understanding the human dimensions of climate change. Such strategies for monitoring climate change will not happen without external motivation and collaboration.

The V&A team is grateful for the opportunity they were given to inform the islanders about their activities on Aitutaki during their stay, including announcing meetings on television. The local television station has been very successful and experience has shown managers are willing to broadcast any interesting environmental programs that they are given, particularly if they have local content. Videos also tend to be shared around reaching a wider audience than might be otherwise expected.

Many of the community centres, shops, and people's homes in Aitutaki appear to appreciate decorating their walls with posters. If effective and colourful posters promoting adaptation strategies are designed and printed on good quality paper, they are certain to be readily accepted and displayed. Similarly, in the resource-strapped schools, distribution of climate change education materials can be achieved for a nominal fee. It is important that individuals understand the reasons for changing some current practices and are encouraged to do something about it themselves. Bottom-up[37] action on common sense adaptive options would be much more effective than top down[38].

Engaging community support and traditional values can reinforce the adaptations recommended for accommodating climate change. For example the disposal of hazardous materials and rubbish in general were once found along the beaches. The Island Government is encouraging the use of more firmly designated areas through their bylaws. Ra'ui imposed by the village leaders and discussed earlier are likely to have positive impacts despite the lack of scientific selection methods. There is scope for strong peer pressure under such schemes as inter-village competitions, as the local people are involved. Also the Aitutaki people need to be provided with alternative options (technology transfer) beyond limited local experience for potential areas of increasing vulnerability, such as the coastal areas as a result of sand mining and other degrading activities.

• Table 2 Summary of Key Reccommendations for Adaptation

Sector	Recommendation
Water	Hydrological monitoring to observe usage patterns and identify improvements. Leak detection programme, replace old water pipes Improve rainwater catchment systems Provide incentives for maintaining guttering and pipes to tanks Ensure that piping is appropriate i.e. rust proof, accessible Maintain the boiling of water as a low cost form of treatment Encourage households to store and conserve their water Introduce a by-law requiring business users to install rainwater tanks and maintain catchment systems

[37] Bottom-up refers to grassroots or individual community level actions
[38] Top down suggests more of a management, policy or regional type approach to actions

	Establish a revolving fund, which could be loaned to households to purchase rainwater tanks and spouting. Use brackish/seawater when appropriate Install cleaner toilet systems e.g. compost toilets, to reduce contamination Have disaster relief supplies ready for import in periods of emergency
Health	Focus on prevention activities through health and education awareness Integrate climate change issues into existing health strategies Vector control programme, prioritising reduced mosquito population and breeding areas Encourage balanced nutrition and food storage Encourage drinking more fluids to avoid dehydration Improve hygiene at home
Biodiversity and the Coastal Zone Ecosystem	Increase awareness of the local community on status of flora and fauna Studies to focus on thorough information Adopt draft environmental by-laws for integrated coastal zone management Set building regulations so that new structures are appropriate for future climatic conditions and incorporate traditional structures that have been suitable Plant appropriate trees and allow coastal trees to regenerate
Agriculture and food security	Reduce pest introduction through improved quarantine procedures Provide updated information on best planting dates to take into account changing climatic conditions Work with Cook Islands Organic Growers association emphasising use of biological control and gentler fertilisers/pesticides/herbicides Improvement of food storage Encourage on-going co-operation with gene bank project in Rarotonga's Ministry of Agriculture to foster resilient crops Increase community awareness through media releases (radio/newspaper) and workshops
Tourism	Enhance concept of ideal eco-tourism destination Increase self sufficiency of accommodation through water catchment/storage Encourage use of alternative renewable energy like solar, wind power,and hybrid generators Increase tourism awareness of climate issues
General	Public education using local media and schools Poster distribution in community and schools

Evaluation of Adapation Options

Much of the discussions about these have already been incorporated in the section describing possible response options. For example, Ocean Thermal Energy (OTEC) was an idea that was put forward in some meetings and then laid aside by the majority of the community because it was not something that could be done at the local level or with the immediacy required to resolve the water issue.. The number one prioritised adaptation option was consistently water tanks, however there was some variation between villages selection of other priority response options within the range of possible solutions suggested.

For health, education, community clean ups and working bees, regular inspections, and spraying, were emphasised to deal with both the vector borne disease and waste management problems. On the coast, the community of one village wanted to see trees preserved or even replanted, and sand mining stopped to slow coastal erosion. In another village enforcement of bylaws on conservation areas (ra'ui) and not leaving gillnets overnight were favoured to improve the lagoon heath. This exercise gives insight to some local adaptation option

preferences although time did not permit detailed evaluation and criteria based selection for all of the sectoral solutions.

[redacted]

4) Approach to Adaptation Implementation

Selection of Adaptation Option

The priority concerns expressed by the Aitutaki people in all consultations centred on the availability of drinking water resources, and water resources were a key part of other problems identified such as health and agriculture. Based on current experience with saltwater intrusion into groundwater, logically rainwater harvesting and storage is being emphasised as a key solution. Under climate change scenarios, salt-water intrusion is expected to increase through sea level rise and more frequent storm surge, while rainfall patterns are likely to alter. Therefore if the Aitutaki community is to cope with this aspect of climate variability and change, a sustainable adaptation option needs to be identified and implemented.

The feasibility from a local perspective of different water resource adaptation options was explored in the village meetings, and the consensus was that support for the provision of household tanks would be essential. The CBDAMPIC Aitutaki project aims to carry though one identified adaptation option to implementation on the ground, and actually improve the ability of people on Aitutaki to cope with an aspect of climate change. Therefore the water tank option was further explored in terms of past experience with tanks and what would enhance the sustainability of water tanks as an adaptation option.

Water Tank Issues to be Considered

The first issue that was discussed was the benefits of household versus community tanks, which are already a feature in Aitutaki. It was expressed that household tanks would address past problems with land ownership, access, neglect, quantity of use issues, and disagreements over responsibility for undertaking maintenance, cleaning and costs of repairs. Many community members believe self-interests will enhance care of the smaller tanks resulting in improvement of water quality and conservation. Depopulation, installation of household tanks by those who can afford it, and changing attitudes within the villages has lead to neglect of many community tanks that are relied on by the less affluent.

In terms of past experience with both household and community tanks a major problem was the lack of repairs, maintenance, and cleaning, particularly of the tank accessories like spouting, roofing, and surrounding area. This has resulted in disused tanks, insufficient water stored, and contamination of tank water leading to high levels of bacteria. Not all Aitutaki tanks have suffered this fate, and many community members pointed to their successful reliance on both self purchased and aid provided tanks for more than the average 20 year lifespan.

Multiple factors contributed to the early breakdown of some tanks, including; exposure and damage during past cyclones, old technology, poor design (shape – square versus round, & size, both affected ease of cleaning and longevity), and quality of building materials – steel girders rusted, asbestos roofing concerns stopped catchment, incorrectly mixed concrete sprung leaks, plastic warped and cracked in the heat or developed excessive algae, lack of covers and filters resulted in mosquito invested and dirty water. A lack of time, finance, expertise, and even basic plumbing materials available on island to maintain the tanks were also pointed out.

Addressing Household Water Tank Issues

Some meeting participants favoured concrete tanks, primarily because they could be locally built, and if done correctly have a longer lifespan, despite being more expensive. However, the majority proposed plastic tanks because they were easier to locate (above or below ground) clean, and affordability might mean the project more households would benefit from the project. Also in favour of plastic were the limited set-up requirements , as the tanks could simply be ordered and shipped inwith the CBDAMPIC project funding and then distributed to the community. Others suggested a kind of vinyl lining that would fit in any supporting mould.

To achieve the project goals tank size would need to be sufficient to actually improve ability to cope with potentially longer climate change induced drought periods, however the community was only able to suggest sizes based on existing experience of tanks used for drinking water and this ranged from 500 Litres - 6000 Litres. The ease of annual draining and cleaning to maintain water quality was a key factor for those favouring smaller sizes. To deal with the issue of water quality a number of people said filters and treatment or purification might be necessary, others advised simple solutions such as screening down pipes, and routines of disconnecting and reconnecting spouting between rainfalls worked well.

Some felt new technologies needed to be explored, including the suggestion that it may be viable to import a plastic injection mould for water tanks and train people to make them locally as a small business. Such a machine may also have other applications through the attachment of different moulds, for example plastic kayaks for the tourism market. If possible CBDAMPIC project would then support the development of more sustainable and market oriented solution than it would by just purchasing tanks. The CBDAMPIC team said that this idea would definitely be explored.

In terms of ongoing maintenance it was proposed by different villages that a tank-monitoring program would be needed. Responsibility for executing this program would fall to specially set up local government, village committees/teams, schools, or the Health department. It was noted the Health department and Environment Service already conduct bi-annual inspections (*Tutaka*) of households in relation to hygiene, pollution, and mosquito breeding areas. Such a monitoring program could involve testing, noting and reporting of leaks, cleanliness, and equipment condition. It was suggested compliance might be better if there were competitions and incentives or public reporting of poor water quality test outcomes.

Selection of Household Water Tank Recipients

The project team noted that CBDAMPIC funding was unlikely to be able to provide tanks for all households, and asked the villagers how they would determine who should get a tank. It was made clear that this would need to be decided by the villages, and they suggested criteria would be based on things like poverty, existing access to tanks, technical requirements like appropriate location and roof type for tank, willingness to assist in helping themselves through cost sharing, fundraising and working bees.

Each village agreed that households would need to contribute something as a prerequisite to being considered for a tank. Options included paying the balance of a subsidised tank, purchase through a revolving fund, and supplying the accessories for tanks such as base, spouting, roofing, purification, materials for or participation in construction etc. It was also suggested that household tank owners might sign a pledge agreeing such things as regular inspections, water quality tests, a program of cleaning and maintenance (working bees), sharing their water with others in need during a crisis, and to fundraise through raffles or other means to replace or repair any damage to their tank after a cyclone.

The CBDAMPIC team advised that the communities needed to be ready provide feedback on criteria once these aspects were further explored and outlined in the project proposal, to see if some or all are appropriate steps. The core group facilitator for each village is to be responsible for circulating the project proposal in the village, and the existing local decision making committees such as the Aitutaki Women's Association and others will determine if the proposal covers what has been put forward in the community meetings.

Related matters

The communities consulted called for local or national government to develop policies and by-laws that would strategically improve the quality and availability of drinking water. This most often referred to mandating monitoring of water quality, but also suggested the removal of levies or subsidising of water tanks and accessories, the requirement of water tanks for all new developments particularly commercial businesses such as tourism industries, and capacity

building to develop skilled plumbers & builders. As many people in Aitutaki get mortgages for building their houses it was suggested the banks could incorporate a budget for a tank into all new loans.

The need for an education and awareness campaign related to water conservation, steps for regular tank water quality maintenance, and promoting building of tanks was highlighted. It was hoped the CBDAMPIC project could instigate this with posters, TV, radio, and person-to-person programs and local government and village committees would then continue it.

Next Steps for Implementation of Household Water Tank Adaptation Option

This report is to be submitted for review by members of the Core Facilitator Group, Aitutaki Climate Change Community Team, Aitutaki Island Government, National Climate Change Country Team, South Pacific Regional Environment Program and Canadian International Development Agency

The Technical Advisor & Aitutaki Coordinator recognise the benefits a fresh perspective and more experience in both proposal writing and the water resources sector would bring. Therefore a Terms of Reference is to be drafted for the writing of the project proposal by a consultant over 10-15 working days.

The project proposal will be circulated to the communities for their endorsement, and then submitted to CIDA for approval to spend funding according to the proposal plan. Given the frequently expressed community concerns about endless studies with little implementation, it is hoped the endorsed proposal will be accepted and the implementation can follow right away.

Implementation will need to be at several levels;

the community form their committees to decide which households require tanks,

development of policies in collaboration with local government and banks commenced,

there may need to be

- tenders or expressions of interest sought in the small business idea, and technical training,

environmental impact assessments of the potential business, tank construction materials and locations,

development of education program by CBDAMPIC team

development of monitoring program by various agencies

approval, reporting and inspection of implementation progress to relevant local, national, and regional bodies

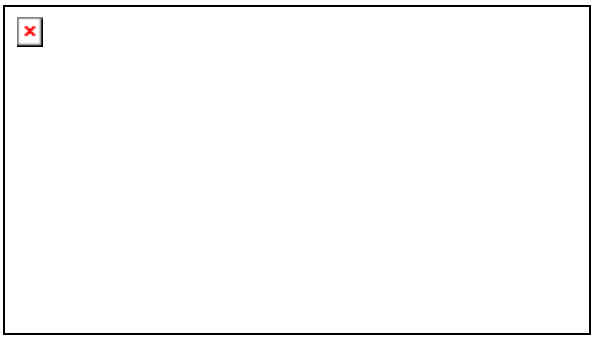
Therefore until the project proposal is complete it will be difficult to determine an exact timeline or resource allocation for the implementation phase of this project to improve the ability of Aitutaki people to cope with climate change.

5) Conclusion

There are a number of problems facing the inhabitants of Aitutaki today, and many are likely to be aggravated by climate change. Based on the Community Vulnerability and Adaptation Assessment, availability of drinking water resources is their most pressing concern due to shifting rainfall patterns (increased drought) and salt water intrusion into the ground water. The island is economically vulnerable to climate change impacts on their tourism and coastal areas. In the future these problems are more likely to be exacerbated by non-climate and climate factors than alleviated.

Global temperature increases are likely to produce extreme events, especially altered rainfall patterns, more hot days, and cyclones. As a result ecosystem changes in both marine and land based resources such as altered growth patterns for agriculture crops and coral bleaching have already been seen.

Accommodating these changes will require a range of adaptation strategies that emphasise practical small-scale projects that can be implemented at the individual household level. Long-term responses will need to address the problem of shorter-term climate variability. However, these adaptation strategies will only be successful if they have the whole community's support and understanding.



BIBLIOGRAPHY

Aitutaki Tourism Taskforce, (1994) Strategic Tourism Development Plan for Aitutaki, Cook Islands Government

Australian International Development Assistance Bureau, (1994) Review of Vaipeka Water Gallery Extension and Water Supply Needs,

Baronie, F, (1995) A Report on the State of the Reef Fish Population, Community Fishing Practices and Tourist Attitudes to Lagoon Issues in Aitutaki, Conservation Service, Rarotonga.

Barret Consulting Group, (1995) Aitutaki Infrastructure Evaluation, Phase I Final Report. For the Office of the Prime Minister. California, USA.

Basset, I.G and K.W. (1968) Thompson Land Use and Agrarian Change on Aitutaki, Cook Islands, South Pacific Bulletin, First Quarter pp25-30

Beaglehole, E., (1957). Social Change in the South Pacific, *Rarotonga and Aitutaki*. Ruskin House, George Allen and Unwin Ltd.

Bertram, I., (1995). The Aitutaki experience in the development of management strategies for the Trochus fishery. Report to Forum Fisheries Agency/South Pacific Commission Workshop on Management of South Pacific Inshore Fisheries, Noumea, New Caledonia, June 26 – 7 July 1995.

Binnie and Partners, (1994) Report on the Water Resources and Water Supply of Aitutaki, Government of the Cook Islands

Cook Islands Statistics Office, Census of Population and Dwellings 1996.

Cook Islands News, Thursday 15th May 2000: Four raúi areas to be declared in Aitutaki pp1

Cook Islands News, Friday 14th July 2000: 20 year weather records broken

Crocombe, R., (Edited). (1987). Land Tenure in the Pacific: The Cook Islands – Fragmentation and Emigration. University of the South Pacific, Suva, Fiji. pp. 59.

Forbes, D. (1995) Coastal Stability and Sand Transport Aitutaki, Southern Cook Islands, SOPAC Technical Report 226, 45p

Government of the Cook Islands, (1993) NEMS

Hoegh-Guldberg, O., (1995). The mass bleaching of coral reefs in the Central Pacific in 1994: A followup study and establishment of long-term monitoring sites. Climate Impacts Series, 2. Greenpeace International.

McCormack, G. and Kunzle, J., (1992). In search of two plants and a bird lost from the Cook Islands. Rarotonga, Cook Islands.

Passfield, K (1993) Survey of the Ootu Fish Nursery Reserve, Aitutaki, with Management Recommendations, Conservation Service, 1993

Paulay, G (1994), The State of the Reef, Aitutaki Surveys, Marine Laboratory, University of Guam, 1994.

Poeschko, M., Arioka, P.A. and Tuaeu, D., (1997). Report on the visit to the island of Aitutaki 17th-19th of November 1997. Pp. 4 -12.

Rongo, T., (1998). Aitutaki Resource Management Policy and Proposed Resource Management ByLaws. Island Friends Cook Islands Ltd.

Saifullah, S. and Mataio, N., (1993). Agriculture in the Cook Islands *New Directions.* Institute of Pacific Studies and the Cook Islands Centre of the University of the South Pacific, Rarotonga and Suva.

Sherwood, A.M. (Compiled)., Howorth, R., and Rodda, P. (Edited). (1997). Coastal and Environmental Geoscience Studies of the Southwest Pacific Islands. Technical Bulletin 9. South Pacific Applied Geoscience Commission (SOPAC); pp. 249.

Singh, R.B.K., Raj, R., Wet de, N. and Hales, S. (2000). The influence of climate variation and change on diarrhoeal disease in the Pacific Islands. Handout to Pacific Islands Climate Change Conference: Linking Science and Policy, April 2000.

Stoddart, D.R.1975 Almost-atoll of Aitutaki, Background and Bibliography, Geomorphology of Reefs and Islands, Reef Islands of Aitutaki, Mainland Vegetation of Aitutaki Atoll Research Bulletin #190

Thompson, CS 1986 The Climate and Weather of the Southern Cook Islands. New Zealand Meteorological Service, Miscellaneous Publication188(2), 69p

ABBREVIATIONS / ACRONYMS

ADB	-	Asian Development Bank
ACCCT	-	Aitutaki Climate Change Community Team
AIACC	-	Assessments of Impacts & Adaptation to Climate Change
AusAid	-	Australian Agency for International Development
CIDA	-	Canadian International Development Agency
CBDAMPIC	-	Capacity Building to Enable the Development of Adaptation Measures in Pacific Island Countries
CLIMAP	-	Climate Adaptation Measures in the Pacific
JICA	-	Japanese International Co-operation Agency
MOU	-	Memorandum of Understanding
NCCCT	-	National Climate Change Country Team
NZODA	-	New Zealand Overseas Development Aid
PACCLIM	-	Pacific Climate Modelling Programme
PICs	-	Pacific Island Countries
PICCAP	-	Pacific Island Climate Change Assistance Programme
PIREP	-	Pacific Island Renewable Energy Programme
SPC	-	Secretariat of the Pacific Community
UNFPA	-	United Nations Population Fund
USP	-	University of the South Pacific
WB	-	World Bank
WHO	-	World Health Organization

TERMS

***Climate Change*:** can be defined as a change in the average climate (or its variability) from one averaging period to the next.

***Vulnerability*:** degree to which a susceptible area or exposure unit is affected or disrupted by climate change.

***Adaptation*:** these are actions or activities that people take in order to accommodate, cope or benefit from effects of climate change.

***Mitigation*:** activities that seek to reduce the build-up of greenhouse gases and other climate modifying constituents.

***Motu*:** these coral islets form as a result of aggregates of reef materials accumulated during normal high seas but mostly during major storms.

***Ra'ui*:** Traditional method for sustainable use of resources.

***Marae*:** Place of worship before Christianity was introduced.

***Agglomerate*:** A product of volcanic eruptions that comprises fragments of solid rock, which because they are hot when they touch the ground, become welded together.

APPENDIX 1

Community Consultation **Methodology**

Step One Problem Identification

The process commenced with the Core Group Facilitator for the village summoning as many people as possible[39] to attend their meeting. Once everyone was assembled, introductory prayers and speeches would be made; prior to the key facilitator Mauke Mauke requesting the village members to throw out issues that they felt were of concern to them. To stimulate discussion and reduce over-focus on the concept of climate change any issue could be put forward. The working language was usually Aitutaki Maori, translated to English lists written up on flip chart paper by a facilitator. The General Problems Table shows the range of issues raised. These were then prioritised by group consensus[40] and some relevance to climate before shifting to smaller groups (up to 10 people), that were given a A3 worksheet each with one of the problems on it.

Step Two Group Work – Cause & Effect

The group work was conducted in two stages. First the groups were requested to write down causes (what caused X to be a problem) & effects (how does X affect your village) around a prioritised issue in a modified problem tree[41] they were given 5 minutes before rotating their sheet on to the next group, which then each had 2 minutes to add any points. In this manner we were able to work through a number of problems and a number of groups in a shorter period of time. With the number one prioritised issue (always water resources) all groups were given the same problem and 5 minutes, each sheet was then rotated for 1 minute per group so all would be able to read what the others had put for causes and effects. The Core Group Facilitators were split into each group as recorders and to guide the village members away from their tendency of jumping to solution identification too soon.

Step Three – Group Work Solution Identification

With some further explanation we then distributed new sheets with the same prioritised issue on each and asked the groups to write down in 5 minutes what they thought were possible solutions to those problems, bearing in mind the cause & effect points they had just made, before sheets were rotated again. As with cause & effect all groups worked on the water resources solution identification simultaneously for 5 minutes.

Step Four – Prioritisation of Solutions and Approach to Adaptation Option Implementation

Returning from small groups to a full meeting format, solutions sheets were put up and solutions were prioritised. In each village we only had time to work on the top 2-3 priority issues and prioritised 2 solutions per sheet. In the first couple of meetings we were very pressed for time by this stage and progressed no further, In the later meetings we were able to enter into some discussion about the approach to the adaptation option implementation and important factors for consideration,

Step 5 Meeting wrap-up.

The CBDAMPIC Team described the project purpose and next steps envisioned. We also left information sheets with the participants and took the opportunity to have informal discussions over the catered meal at the end. As well as being asked to continue to think about the project adaptation option implementation when they went home, information sheets included questions such as have you noticed how much unusual weather has been in the news lately? Are big waves, cyclones, floods, droughts and other extreme events affecting us in the Cook Islands? How does climate influence our lives? What would you do to prevent or prepare for long-term changes and more extreme events in our usual climate?

Assessment Area: AITUTAKI (ARAURA ENUA)

Location & Geography:

- Table 1: Physical Statistics

Land Area		1805 Ha
Arable soils	Class 1	930 Ha
	Class 2	471 Ha

[39] The meetings were also advertised on local Televisi on

[40] Subsequent participatory approach training suggests that rather than verbally prioritising, whereby the more assertive people dominate, a quick inclusive approach is to give all participants 4 sticky dots to place next to their top priorities – the number of dots reflects the relative importance.

[41] The concept of a problem tree was foreign and tended to make people focus on agriculture rather than the actual problem at hand

Reef Circumference			43 km
Transport			
	Roads	Sealed	16 km
	Roads	Unsealed	45 km
	Air		6 days per week
	Airstrip (length)		1,600 meters
	Shipping		Fortnightly
Distance from Rarotonga			277 km
Distance from nearest inhabited island			210 km (Atiu)

Geology:

The southern group comprises two parallel volcanic chains of islands extending over 2600 km. The northern chain extends from the Austral Islands of Rapa and Marotori in the Southeast to Palmerston atoll in the north-west, and it is along this chain that Aitutaki is located[42]. The island of Aitutaki is an example of a partially submerged volcanic island, having the features of both volcanic island and an atoll. Exposed volcanic rocks distinguish Aitutaki from fully developed atolls in which the volcanic foundation is completely buried by a limestone cap and submerged below present sea level[43].

The map of 'almost-atoll' Aitutaki (Figure 2) shows in addition to the main island there are 15 *motu*[44] found mostly on reefs flats having a combined land area of 18.1 km^2. The main volcanic island, located on the north-western reef rim, has a surface area of 16.8 km^2 and rises to a maximum height of 124 metres at Maungapu. The island is surrounded by barrier reef with a shallow lagoon[45] area of 66 square kilometres. Volcanic basalt and agglomerates[46] are also seen near the southern reef rim in the motu Rapota and Moturakau. On these motu the agglomerates include coral fragments, indicating that the latter stages of volcanic activity happened at the same time as reef growth. The atoll characteristic motu are restricted to the eastern reef rim from Akitua in the north to Motukitiu in the south[47], originating as rubble banks on the windward coast during storms, since cemented and planed down[48].

The Aitutaki lagoon is exceptionally shallow, with an average depth of about 5 metres and maximum depth of 10 metres. The lagoon is enclosed by a well-developed barrier reef. There are no natural reef passages but water exchanges between the lagoon and ocean is primarily by wave-driven currents over the shallow barrier reef rim[49]. The lagoon and reef deposits are carbonate (from coral), whereas the lagoon beaches of the main island contain a significant mixture of volcanic sediment.

The uninhabited atoll of Manuae is traditionally regarded as part of Aitutaki. It has a lagoon that is well stocked with fish. Access is usually by pleasure boat and fishing fleets. An airstrip is rarely used

Current Systematic and Observational Networks

Like Mangaia, Mauke, Manihiki, Pukapuka and Tongareva, Aitutaki has had an automatic weather station (AWS) since 1996 when the government meteorological service officer was made redundant during the economic reforms of that period. Synoptic three-hourly weather reports are interrogated from a platform on each of these islands by modem in the main Rarotonga office. These provide the Cook Islands Meteorological Service with the daily weather readings, along with information for organisations like the World Meteorological Organisation (WMO) and the Australian National Tidal Facility (NTF) who are carrying out readings to assess climate patterns globally. The

[42] Sem, Graham, and Stoddart et al 1990.
[43] Forbes, D (1995)
[44] motu is the Polynesian term for small islets
[45] The lagoon has an average depth of 5 metres
[46] agglomerates are volcanic rocks consisting of rounded and angular fragments fused together
[47] Stoddart, D.R. & Gibbs P.E. (1975).
[48] Mclean and Hosking, 1991, pp.247
[49] Sherwood, A.M. et al., (1997).

• Figure 19 A solar powered Automatic Weather Station

Cook Islands Meteorological Service has over 30 years of Aitutaki baseline rainfall and temperature data to draw on. This meets the IPCC[50] guidelines for meaningful data trends.

CLIMATE SCENARIOS

The approach to climate projections uses a **scenario generator** developed by the International Global Change Institute (IGCI). This links together historical climate data (rainfall and temperature), patterns of climate change from global climate models, and outputs from a global temperature and sea-level change model called Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC).

A General Circulation Model (GCM) is a physically based climate model that takes into account in its calculations as many as possible of the factors that would influence global climate. The model runs on a relatively coarse resolution (several kilometres in grid) and several vertical levels. Great uncertainties may result from the coarse resolution used and from the limitation of the current human knowledge of how these factors affect the future climate. In PACCLIM[51], this assessment team uses one GCM, namely CSIRO9. However, more GCM outputs could be integrated to assess the output uncertainties.

Like most Pacific Islands the Cook Islands do not have a specific scenario generator. If feasible it is important for each island group to have its own scenario developed due to the unique geographic location and type of each island resulting in different potential impacts and requirements. For now, the islands in the region rely on the PACCLIM program developed by IGCI. This allows the manipulation of a range of variables based on at least 30 years of real data to produce scenarios of climate change as a result of global warming trends. These estimates vary due to the "what if" nature of the models.

Although the capacity for generating two types of climate change scenario is available, it was decided to used the linked model approach over the synthetic model because it uses real data and will be internally consistent. The linked model takes MAGICC outputs of global temperatures and sea level rise (SLR) and scales them for the Cook Islands region. Within the linked model a selected emissions scenario is required. The Inter-governmental Panel on Climate Change (IPCC) policy scenarios incorporate socio-economic impacts on greenhouse gases, and thus there are variations to indicate the potential range of international responses to reduce emissions, from no action to complete Kyoto Protocol Compliance.

This report relies on six of these emissions scenarios: 1992 (a to f) amended for IPCC 1995 with SO2 regionalised. The extreme range of possible changes is given, although it is likely that real changes will fall somewhere in the middle. To give a picture of what may happen at different stages in the future, the selected time horizons for the scenario projections are 2020, 2050, 2100. These can indicate if Tongareva people have time to respond to any potential impacts on their lifestyles and whether climate changes may accelerate through the century.

Temperature and Rainfall Scenarios

Global average temperature has increased by one degree centigrade in the past century. Based on PACCLIM's warming scenario the temperatures for the Cook Islands can be expected to increase as shown in Table 1, below. Based on the socio-economic factors in the various IPCC models, it is likely that the actual value for average temperature increase will be midway between the two extremes.

• Table 3 Extremes of Temperature Increases Under IPCC 1992(a-f)

Temperature (°C)	2020	2050	2100
Maximum increase	0.6	1.4	3.5
Minimum increase	0.3	0.5	0.9

As Aitutaki usually has marked wet and dry phases through the year, rainfall has been modelled on a six month seasonal basis, but as altered climate cycles already appear to be affecting Aitutaki the earliest time horizon results for precipitation are also presented. The flag values in Figures 1 and 2 shows that the next twenty years rainfall between November to April is expected to increase somewhat, giving the Cook Islands a wetter wet period. On the other hand between May to October a change to a dryer dry period is expected.

[50] Intergovernmental Panel on Climate Change (IPCC) is a large group of scientists who publish research on climate change to help decision makers in planning for the future.

[51] PACCLIM is generated circulation model specifically developed for Pacific Islands situation including the Cook Islands.

Sea level rise scenarios:

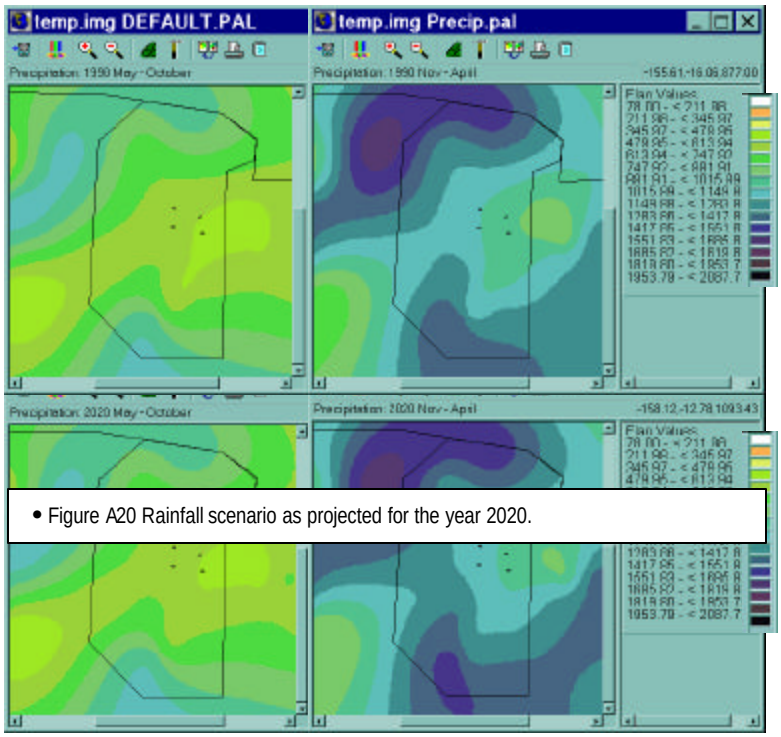
The range of sea level changes for Aitutaki and Cook Islands region were based on the IPCC low, best guess, and high estimates of greenhouse gas emissions under different socio-economic models, and these scenario results are given in the Table 2 below. The projections

- Table 2. Scenarios of Sea Level Rise Increase under IPCC 1992 (a-f)

show significant increases in regional sea level at different time horizons. This gives an estimate of potential sea level changes for the Cook Islands, although not exactly for Aitutaki. From the 1990 baseline benchmark set at zero or the reference point, sea level can be expected to increase by a maximum of 16 centimetres in the next twenty years, although the IPCC best guess value is about half that at 8 centimetres.

Sea Level Rise (cm)	2020	2050	2100
Maximum SLR	16.3	40.2	94.0
Minimum SLR	2.6	6.3	13.1

In Aitutaki, the main impact of sea- level rise will be felt through the change in frequency of storm surges that are able to wash a vast area of land further inwards from the high tide mark. Storm surges occur when tides are high and depressions move through to give sudden rises in sea level above a particular height. When the sea level is higher the return period (average length of time between occurrences of this height) is shorter.



- Figure A20 Rainfall scenario as projected for the year 2020.

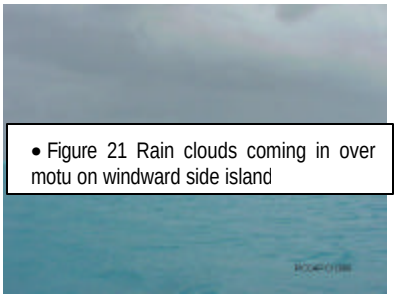
Temperature

Aitutaki's temperature, like every small island surrounded by ocean, tends to vary with the influence of the trade winds blowing from the southeast but have a relatively narrow range. The average wind speed is 5 knots in the mornings and 6 knots in the evenings. Temperatures are high throughout the year, and the daily and seasonal variations are quite small. At latitude 18º52' Aitutaki experiences an average daily range of 5°C, and a seasonal variation of 3°C.

Maximum temperatures over 32°C are experienced on about three to five days each year. A record high temperature of 35.6°C was recorded in February 1933, whereas minimum temperatures rarely fall below 18°C, occurring on only two or three days each year. The lowest temperature recorded to date was 12.8°C in July 1940. Currently the island temperature averages 25.3°C, down from a 24 year high of 27.2 for 1998[52].

Precipitation

There is marked seasonality in the annual rainfall range of 1900mm –2000mm, one third usually falls during the winter dry season (May to October) and two thirds in the summer wet season (November to April)[53]. During the winter long dry periods are likely with an average humidity of 84 percent, while in summer rainy periods are common with higher average humidity of 87 percent, especially when disturbances are developing. There is a considerable variation in seasonal distribution of rainfall from year to year. For example in 1998 Aitutaki rainfall was only 1109mm, while a few years before in 1994 it was 2, 222mm. The inter-annual variability of rain days is more evident in low-lying Aitutaki than the higher southern Cook Islands. The number of rain days of at least 0.1 mm has varied from 105 days in 1946 to 231 days in 1973.



• Figure 21 Rain clouds coming in over motu on windward side island

• Table 4 Average Number of Rain Days of at least 1mm in Aitutaki

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry
133	14	15	15	12	11	8	8	8	6	9	9	13	80	53

The above pattern is mainly associated with the seasonal movement of the South Pacific Convergence Zone (SPCZ) where great amount falls during the summer months (wet season). El Niño events also have a great effect on the rainfall distribution usually bringing less than the normal rainfall.

Extreme Events

Global warming is a result of increased solar energy being trapped within the earth's atmosphere, and thus it may be that Aitutaki is exposed to more extreme climate patterns in the future. Climate variability has yielded floods, droughts, storm surge, and cyclones in Aitutaki in the past. Cyclones are associated with warmer conditions as sea surface temperature has to be greater than 27°C for cyclone formation.

El Niño Southern Oscillation (ENSO)

ENSO is a naturally occurring climate phenomenon, associated with extensive warming of surface waters in the central and eastern tropical Pacific Ocean near South America. Extreme events are often linked to changes in the Southern Oscillation Index (SOI), which measures pressure differences between eastern and western sides of the

[52] The Meteorological Services Director Arona Ngari and his staff were most helpful in giving us updated records and raw data. These need to be analysed further and presented graphically for clarity.

[53] While general observations are found in many studies, a most useful reference although somewhat outdated was the Climate and Weather of the Southern Cook Islands by C Thompson 1986.

• Figure 22 El Niño Diagram from Lobban, C.S., and Scxhefter, M. (1997). Tropical Pacifc Island Environments. University of Guam Press

Pacific. The SOI changes to the global climate are driven in part by solar energy causing greater pressure differences than normal around the Pacific Rim and tend to fluctuate every three to seven years[54].

The two extremes are El Niño, higher than usual pressure in Darwin, tied to the opposite climate from normal, droughts in Aitutaki, and La Niña, higher than usual pressure in Tahiti with more extreme versions of normal seasonal patterns. During the El Niño phase the Southern group experiences a rainfall reduction by up to 60% of the average annual rainfall, while La Niña typically brings more rain than usual. Although the El Niño phenomenon is not well understood in Aitutaki related impacts on the island environment over the past years have been recorded. For example the mass coral bleaching associated with high sea surface temperatures in the early 1990's affected reef systems considerably[55].

Tropical Cyclones

The island of Aitutaki lies within the cyclone belt or path, where housing, infrastructure and agriculture are severely damaged once or twice every ten years. On average there is one tropical cyclone per year of varying intensities, but there are many years when no cyclones approach. Cyclone season lasts from November to April, during the warmer months when the sea surface temperatures can exceed 27°C. The combination of warm sea surface temperature and low-pressure weather systems are required for a cyclone to form. Severe storms and squalls are also reported during this period often causing minor damage to the island and making fishing difficult.

• Figure 23 Coastal Infrastructure (wharf area) at risk during cyclones

Drought

Drought is quite common in Aitutaki. Most droughts are reported to have occurred during the dry season and a distinction is made between a dry spell and very dry period. The number of dry spells is relatively high at 13.7 per decade compared to very dry periods at 6.3 per decade. In 1983 the worst ever drought experienced was attributed to the influence of the El Niño episode[56]. Lack of water in individual homes was a problem throughout the island and devastated all agriculture. The community tanks were used up and people were collecting water by bucket from water holes such as in Vainamu.

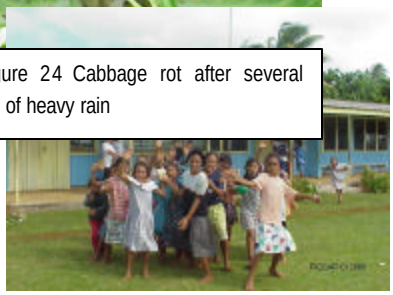
Floods

Because of the limited volcanic sediment to trap moisture for long, floods are rarer and more of an inconvenience than a major concern. Growers find heavy prolonged rains often promote fungal problems with their crops.

• Figure 24 Cabbage rot after several days of heavy rain

Sea Level

The semi-diurnal tides at Aitutaki have a limited range, from 0.49m at springs, to 0.12m at neaps[57]. The mean sea surface temperature ranges from 25.5ºC in June to 27.3ºC in January. Unfortunately, The recent trend in sea level for the Cook Islands is a rise of 7.5 millimeters a year. This is based on 85 months of the Cook Islands SEAFRAME data to April 2000. Longer data recording is needed for reliable measurements of sea level rise. Aitutaki does not have specific sea level and surface temperature variation data since readings are based at Avatiu wharf in Rarotonga. However the islands are close



[54] Kaluwin, Aung, and Lennon, 1997
[55] Hoegh-Guldberg, O., 1995.
[56] According to Tiraa Arere (Agriculture Officer for Aitutaki)
[57] Stoddart, (1975)

enough that there may be little difference in the sea level changes.

Appendix 2:

History

According to oral history, the island of Aitutaki was first settled in 900AD and one of its great legendary Polynesian discoverers was Ru who named it Utataki Enua O Ru Ki Te Moana translated as 'The leading of a cargo of people by Ru over the ocean'. It is from this that some claim that the origin of the island's name came from, while others say it is from the warrior called Utataki-Enua. Another early name for the island is Araura meaning 'fragrant wreaths for dancing', and this name still used today. The present day name for the island of Aitutaki is based on the story of Te Erui, who with his brother Matareka went in search of the land of light. They found a half-sunken island, which they began hauling up. Te Erui called the land they pulled up ? Aitutaki (god-led). Aitutaki has long been a destination of ocean voyaging of the great Polynesian people.[58]

• Figure 25 Children at Vaitau Primary School

The island's first European contact came in April 11, 1789 when they were 'discovered' by Captain William Bligh as one of the first Europeans to set foot on Aitutaki from the *HMS Bounty'.* He returned in July 25, 1792, when engaged for the second time in search for *breadfruit* to take to the West Indies, shortly prior to the famous Mutiny[59]. Reverend John Williams arrived on October 26, 1821 and introduced Christianity by leaving two of his Raiatean teachers Papehia and Vahapata who rapidly succeeded in converting the Aitutakians. Most of the native gods and *marae* were burnt down and abolished where Christianity took over. In 1839, the first European missionary, Henry Royle, took up residence. As with the other islands in the Cook group, Captain Bourke of the HMS Hyacinth, hoisted the British flag in 1888, to annex the island to Great Britain. In 1901, it was included in the boundaries of New Zealand.

Local Government, Ministry of Outer Islands Administration and other Government Departments Statistics

Aitutaki, like all of the other islands of the Cook Islands is governed locally through the Island Council and the Ministry of Outer Islands Development (OMIA)[60]. The government is committed to a program of devolution through the creation of OMIA, followed by strengthening and capacity building of the Island Council. OMIA was set up in 1994 under the Ministry of Outer Islands Act. This specifies and provides for OMIA's functions and powers. The Act was amended in 1995 under which the Ministry was given the power to administer Island Government elections and to assist in the administration of Island Governments generally. OMIA is responsible for governance, infrastructure and utilities, economic development, education, health services, and police services on all outer islands. OMIA operates a decentralised structure through

• Figure 26 Monument commemorating Christian Missionaries

[58] http://www.ck/aitutaki.htm , Earliest known settlement dates in Aitutaki (Urera) 969 ?83 (Bellwood, 1978a)pp231 Pacific Island Lanscapes, Patrick D. Nunn.

[59] Beaglehole, E., 1957. – *Breadfruit (Artocarpus altilis)* a tropical tree that bears fruit seasonally, valuable source of starch.

[60] The name of the outer island administration department has been changed since the writing of this paper to Office of the Minister for Island Administration (OMIA)

offices in all outer islands including Aitutaki[61].

Plans are that the functions of OMIA will be transferred to the Island Government so that there will be full devolution. The provisions of the Outer Islands Government Act 1987 as amended govern local government on Aitutaki. This legislation governs the island councils. The 2000 Aitutaki Island Government was:

Mayor –	Teokotai Herman
Deputy Mayor –	John Baxter Junior
Chief Executive Officer/Is Sectretary –	Sabati Solomona
Councilors –	Temanu Unuka (Vaipae), Victor Herman (Tautu), Johnny Tearetoa (Nikaupara), Tunui Mati (Reureu), William Hewitt (Arutanga), John Baxter (Ureia), Terepoto William (Amuri), Kamoe Tupou (Vaipeka).
Aronga Mana –	Tika Ariki, Niua, Vitariro, Teango, Tangaroa Ariki
Ariki –	Tamatoa Purua, Vaeruarangi Charlie, Manarangi Ariki, Teurukura Ariki
Members of Parliament –	Teina Bishop (Nikaupara/ Reureu), Paora Teiti (Amuri/Ureia), Kete Ioane (Vaipae/Tautu)

Elected representatives currently have a three-year term of office. The first election for the Mayor and Councilors under this Act took place in 1998. Major functions of the Island Government comprise; passing and administering ordinances and by-laws, assisting in the coordination of activities relating to economies, assisting national government in governance and social development, and advising on disputes

Government Representative (GR)	- Tai Strictland
Senior Finance Administration Officer	-
Ministry of Outer Island Development (OMIA)	
Agriculture	- Tiraa Arere
Education (Principal) Araura College	- PunaTupuariki
Health	- Mataiti
Internal Affairs	
Welfare	-
Youth and Sports	
Energy (Power Supply)	
Cook Island Savings Bank (CISB)	-
Justice	-
Police	-
Customs	

• Table 16: Electricity Generated

Year	Kwhrs '000
1996	1,756
1997	1,831

[61] CEO during community consultations until 2003 was Tarota Tom

1998	1,643
1999	1,751
2000	2,231

Source: Cooks Islands Statistics Office.

The equal ratio of males to females did not change between the last two census years

Table 5 Aitutaki Population	
Census Year	No. of People
1902	1,170
1906	1,162
1911	1,237
1916	1,302
1921	1,373
1926	1,431
1936	1,719
1945	2,356
1951	2,396
1956	2,565
1961	2,582
1966	2,579
1971	2,855
1976	2,423
1981	2,335
1986	2,390
1991	2,357
1996	2,389
2001	1,800

Table 3: Population by Gender and Five Year Age Groups

	Total	<5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	>79
Total																		
1996	2272	304	321	291	212	169	166	156	125	101	77	82	85	77	40	28	16	22
2001	1743	148	229	254	179	82	86	125	112	102	73	72	80	70	70	26	18	17
Male																		
1996	1158	158	162	155	109	90	71	91	60	49	38	44	42	44	19	14	5	7

2001	889	81	117	140	94	38	43	54	57	56	30	37	42	37	38	15	5	5
Female																		
1996	1,114	146	159	136	103	79	95	65	65	52	39	38	43	33	21	14	11	15
2001	854	67	112	114	85	44	43	71	55	46	43	35	38	33	32	11	13	12

The loss of young children was the main reason that the dependency ratio fell from 94 dependents for every 100 economically active persons in 1996, to 91 dependents for every 100 in 2001Source: Cook Islands Statistics Office.

The 2002 total enrolment of 595 was down 30% on the 1996 level, and almost 70% of the population held no qualification in 2001.

• Table 5: School Population

1996	1997	1998	1999	2000	2001	2002
855	763	726	710	651	642	595

Sources: Cook Islands Statistics Office; Education Statistics Gazettes, 2000 , 2001, 2002.

Table 6 shows the breakdown of the school population by grade. In 2002, there were 289 primary school students spread fairly evenly through the grades, and 264 secondary school students. While over 90% of those enrolled in grade 6 of primary school enter Form 1 of secondary school, the retention rate at the upper secondary school level falls off, as indicated by comparisons of Form 5 with Form 6 enrollments.

• Table 6: School Rolls by Grade

	PreSch	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	F 1	F 2	F 3	F 4	F 5C	F 5N	F 6	F 7	Total
1996																
Amuri Primary	23	6	12	15	9	12	9	0	0	0	0	0	0	0	0	86
Araura Primary	47	20	21	34	34	28	35	0	0	0	0	0	0	0	0	219
Vaitau Primary	52	29	25	18	19	19	17	0	0	0	0	0	0	0	0	179
Aitutaki SDA	13	7	7	10	4	11	3	0	0	0	0	0	0	0	0	55
Araura College	0	0	0	0	0	0	0	50	63	58	41	61	23	20	0	316
2000																
Amuri Primary	6	18	6	11	1	10	2	0	0	0	0	0	0	0	0	54
Araura Primary	10	47	25	34	28	30	26	0	0	0	0	0	0	0	0	200
Vaitau Primary	26	10	16	19	17	11	22	0	0	0	0	0	0	0	0	121
Aitutaki SDA	8	6	5	6	3	3	5	0	0	0	0	0	0	0	0	36
Araura College	0	0	0	0	0	0	0	51	50	48	40	21	17	13	0	240
2001																
Amuri Primary	0	9	7	5	11	1	8	0	0	0	0	0	0	0	0	41
Araura Primary	8	44	30	23	26	23	26	0	0	0	0	0	0	0	0	180
Vaitau Primary	9	23	10	15	12	17	11	0	0	0	0	0	0	0	0	97

Aitutaki SDA	5	13	3	6	9	5	9	0	0	0	0	0	0	0	0	50
Araura College	0	0	0	0	0	0	0	51	53	54	43	33	20	20	0	274
2002 (all schools)	42	49	45	47	51	53	44	52	43	49	39	0	60	21	0	595

Source: Education Statistics Gazettes, 2000, 2001, 2002.

There were 41 teachers in Aitutaki in 2002, 38 of whom were certified and 7 of whom held bachelors' degrees. The percentage of female teachers has increased markedly in recent years, while the student:teacher ratio has remained low.

Tertiary and vocational opportunities generally have not been available on Aitutaki, except for the occasional training program offered through the Small Business Center, NGO's such as Punanga Tauturu or Government agencies such as OMIA, Agriculture, Internal Affairs and MFEM. However, some training needs are being addressed in 2002/2003 and 2003/2004 through a training program initiated by the Department of National Human Resource Development (NHRD) in partnership with OMIA, the University of the South Pacific and NZAID. This will encompass vocational training in mechanics, carpentry, plumbing and electrical skills, and access to a bachelor's degree in business administration and computing. In the calendar year 2002, three Aitutakians undertook training in carpentry, and two in automotive mechanics.

• Table 7: Teachers by Gender, Teaching Level, Nationality and Qualification

	Teachers			Teaching Level			Nationality		Qualifications		S.T
Year	Total	Female	%Female	Pre-school	Primary	Secondary	Cook-Is	%CIs.	Degree	Certified	Ratio
1998	41	11	30	5	18	18	36	5	3	17	16
1999	45	11	34	4	21	20	40	5	4	38	14
2000	44	31	70	4	20	20	41	93	6	41	16
2001	44	33	75	4	20	20	41	93	8	38	16
2002	41	30	73	3	19	19	39	95	7	38	14

SOURCE: EDUCATION ST ATISTICS GAZETTES, 2000, 2001, 2002.

Table 10 shows the highest educational qualification gained by the resident population over 15 years. It is notable that 71% of the male population and 68% of the female population held no qualification, which are extraordinarily high percentages even by outer island standards. Only 1% of females and 1.5% of males achieved university entrance level.

Table 10: Highest Qualification Gained for Population Aged 15 Years and Over

	Total	CI School Certificate	NZ School Certificate	Higher leaving school ceriticate	Form 6 Certificate	NZ Bursary Award	University Entrance	Certificate	Diploma	Bachelors Degree	Qualification Stated	Not Stated	No Qualification
2001	1112	95	126	23	48	18	14	3	1	3	7		774
Female	561	64	64	11	18	9	6	2	1	1	3		382

Source: Cook Islands Statistics Office.

In 2001, there were 1,112 Aitutakians aged 15 years and over (Table 3). Of these, 603 (54%) were classified as economically active in the sense that they were employed (519 people) or unemployed but seeking work (84 people).

Average weekly household income from all sources was $269 ($251 exclusive of taxes and superannuation payments). Subsistence production accounted for $41 or 15% of this income, Remuneration from wages and salaries provided 56% of total income, Social welfare payments provided 10% of total income and cash or goods received from friends and relatives provided 8%.

Average weekly household cash expenditure was $211, which almost exactly matched available cash income. The weekly food bill accounted for 37% of household expenditure and primarily involved purchase of meat, fish, and poultry, cereal and cereal products, and bread and biscuit products. Housing and household operations absorbed 36% of weekly expenditure, with transport being the next major item at 13% of weekly outgoings.

In December 2002, there were 623 welfare (child benefit, disability, old age pension) beneficiaries representing 35% of the population. Males have dominated the old age pension category since 1997. Banking services are provided by branches of the Bank of the Cook Islands, Westpac and ANZ, and the island will have its first cash machines in 2004. There is a local market every day except Sunday, which offers vegetables, coconuts, clothing and handicrafts. The market building also serves as a general meeting place.

Table 9 presents a breakdown by gender and activity of the 1,112: half were female; 30% were engaged in home duties; 45% were employers, self-employed or working fulltime; .9% were students; and just under 2% were working part-time or as unpaid family laborers. The unemployed and retired made up 8% and 7% of the total, respectively.

• Table 9: Population Aged 15 Years and Over by Gender and Activity Status, 2001

	Total	Employer	Self Employed	Working Full	Working Part	Unpaid Family	Student	Un - Employed	Home Duties	Retired
1996	1,360	34	23	277	48	68	15	101	692	102
Male	683	26	16	151	33	58	10	40	289	60
Female	677	8	7	126	15	10	5	61	403	42
2001	1,112	33	40	427	11	8	98	84	336	75
Male	551	25	25	250	6	3	50	40	102	50
Female	561	8	15	177	5	5	48	44	234	25

Source: Cook Islands Statistics Office.

Table 11 provides additional information on the source of employment in Aitutaki. In contrast to the situation in other outer islands, the public service downsizing that was central to the post-1995 economic and public sector reforms seems to have been durable. Public service numbers have dropped since 1996 and private sector employment has expanded, providing 54% of employment in 2001, while the public service provided 22%. There has been a marked rise in employment with non-government, including overseas, organizations.

• Table 11: Total Employed Population by Principal Employer

	Total	Public service	Private Enterprise	Ad-hoc Organizations	Overseas Organizations	Religious Organization	Self-Employe

						s	d
1996	394	124	236	11	0	6	17
2001	519	114	281	36	76	8	4

SOURCE: COOK ISLANDS STATISTICS OFFICE.

Table 12 shows that 24% of the 2001 population over 15 years of age reportedly received no (cash) income, compared with 42% in 1996. There were roughly equal numbers of men and women in this category, reflecting heavy involvement in subsistence production and home duties, respectively, although Aitutakian women do not produce handicrafts production to the same extent as in other Southern Group islands. Almost 41% of the female population earned less than $5,000 per year, compared with 25% of the male population. Correspondingly, males dominated the over $5,000 categories. Over 22% of the population aged 15 years and over earned $10,000 or more per annum.

Table 12: Income levels of the Population Aged 15 Years and Over by Gender

Year	Total	No Income	Less Than $5,000	$5,000 - $9,999	$10,000 - $14,999	$15,000 - $19,999	$20,000- $29,999	$30,000 - $39,999	$40,000 - $49,999	50,000 - $59,000	>$59,000
1996	1360	575	515	173	54	17	16	6	2	2	
Male	683	327	200	97	27	10	13	5	2	2	
Female	677	248	315	76	27	7	3	1	0	0	
2001	1112	264	367	229	130	61	34	12	6	1	3
Male	551	131	138	134	74	36	20	7	4	1	3
Female	561	133	229	95	56	25	14	5	2	-	-

Source: Cook Islands Statistics Office.

PRIVATE SECTOR

The total number of active businesses by industry on Aitutaki was 49 in 1999. By industry these were:

in agriculture and fishing

in mining, quarrying and manufacturing

in building and construction

in trade, restaurants and accommodation

in transport and communication

in finance and business services

in community and personal services.

More recent detailed information for businesses outside of the tourism sector is not available, but it is clear that there has been significant private sector expansion in the last few years.

The Outer Islands Development Grant Fund (OIDFG) has been introduced to support community and private sector development in the Outer Islands. Between November 2001 and March 2002, $113,00 in funding was approved for five projects as follows:

Gina's Garden Lodge	swimming pool
Araura Bakery	bakery
Aitutaki Producers' Assoc	nursery equipment
TK's Crafts	house for craft sales
Te Tiare	vehicle for carting

WELFARE

Welfare benefits provide a social safety net for the population. Old age pensions of $220 per month are paid all adults from the age of 60 years. A destitute or infirm allowance of $120 per month is paid to persons who are unable to support themselves and their dependents. A child benefit allowance of $60 per month is paid for all children up to the age of 10 years.

• Table 8: Welfare Beneficiaries 1997 – 2002 by Gender

	1997		**2001**		**2002**	
	Male	Female	Male	Female	Male	Female
Old Age Pension	91	81	98	90	93	87
Child Benefit	330	267	201	184	199	186
Infirm/Destitute	33	42	26	31	29	29
Total Beneficiaries	454	390	325	305	321	302

Source: Ministry of Internal Affairs.

Crops grown for commercial purposes are largely vegetables and to a lesser extent root crops such as cassava and tarua. Aitutaki is probably the second most productive agricultural island after Rarotonga, comprising 930 hectares of class one[62] arable land. (Table 3, Appendix 2). Most crops are grown primarily for subsistence with people producing enough to feed and support themselves.

[62] Arable land - Class 1: Land which is suitable for cash and subsistence crops, including vegetables. Class 2: Includes lands which is suitable for tree crops only. (Mataio, N. and Syed, S., (1993).

• Table 13: Agricultural Activities

	No. of Households	Subsistence Only	Subsistence with Cash Cropping	Mainly Commercial	Minor Agricultural Activity	No Agricultural Activity
2000	444	236	33	19	148	8

SOURCE: MINISTRY OF AGRICULTURE 2001, *COOK ISLANDS 2000 CENSUS OF AGRICULTURE AND FISHERIES.*

• Table 6 Some Types of Agriculture crops grown in Aitutaki

Vegetables	Root Crops	Fruit trees	Others
Cabbage, lettuce, capsicum, tomatoes, carrot, spring onion, watermelon, chinese cabbage, spring onion, rau pele (rukau viti), chillies, eggplant, cucumber, beans, cauliflower	Tarua, cassava, kumara, taro, puraka, yam	mangoes, pawpaw, lychee, vikakava, carambola, kaika, avocado, breadfruit, citrus, banana	Vanilla, pineapple, coconut, nono

Aitutaki's forests can be described as principally bush and fernlands with the main tree species being Coconut (*nu*), Mango (*vi*), Tree hibiscus (*au*), Pandanus, Ironwood, and the more recently introduced Java Plum (*pistati*).

Introduced weeds such as the thorny giant sensitive plant *(Mimosa invisa)* and Mexican sunflower *(Tithonia diversifolia)* grow wild throughout the island and threaten the island's biodiversity. Biological control of weeds and pests is an important alternative to reduce chemical usage on the island. The introduction of psyllid bug *Heteropsylla spinulosa* in 1994 by the Ministry of Agriculture for the Giant Sensitive plant (*Mimosa invisa)* has had promising results for controlling the weed [63] and the ladybird *Chilocorus circumdatus* has been effective for citrus snow scale *Unaspis citri* and coconut scale *Aspidiotus destructor*. Of course history has shown that not all biological controls end up doing what they were meant to and can become pests themselves, including the indian myna bird which was brought in to control stick insects on coconut trees and has now become a dominant bird species attacking fruit.

• Figure 27 Aitutaki Grassland

• Figure 28 Mexican Sunflower

• Table 7 Total Number of Livestock in Aitutaki 1996 Census

Pig	Goat	Cattle	Chicken
2,654	634	103	4,837

[63] Poeschko, M. et al., 1997.

• Table 8 Distribution of Arable Land by Island in Acres[64] *(percentages in brackets)*

Island	Total Land	Arable Land (% of total)	Class 1 Land (% of total)	Class 2 Land (% of total)
Rarotonga	16,509	5,226 (32)	3,697 (71)	1,529 (29)
Aitutaki	4,519	3,455 (76)	2,292 (66)	1,163 (34)
Mangaia	12,791	6,300 (49)	1,042 (17)	5,258 (83)
Atiu	6,643	4,542 (68)	1,158 (26)	3,384 (74)
Mauke	4,544	3,917 (86)	1,054 (27)	2,863 (73)
Mitiaro	5,507	2,526 (46)	272 (11)	2,255 (89)

Adapted from: Saifullah, S. and Mataio, N., (1993). Agriculture in the Cook Islands *New Directions,* pp. 37.

Boats must travel slowly through the ra'ui area and have no fishing equipment on board.[65] In particular the mudflat of Ootu has heavily exploited in past years. This area of the coast is exceptionally surrounded with paspalum or sea grass marsh . These salt marshes provide homes for marine and terrestrial animals such as the butcher land crab tupa (*Cardisoma carnifex*), banded prawn killer varo (*Lysiosquilla maculata*), and are an important breeding ground for fish.[66].

Most coastal vegetation is typical of the atoll like environment with vines, shrubs and trees. Species include vines of ipomea (*Ipomea pescarprae*), shrubs such as ngangie (*Pemphis acidula*) ngahu (*Scaveola taccada*), and trees like toa (*Casuarina equisetifolia)*, au *(Hibiscus tiliaceus*), tauhinu (*Messerschmidia argentea*), ára (*Pandanus tectorius*), 'ano (*Guettarda speciosa*), tamanu (*Calophyllum inophyllum*), nono (*Morinda citrifolia*) and the common coconut (*Cocos nucifera*) grow abundantly around the coast.

Table 14: Fishing Activities

	Total Households	Subsistence Only	Subsistence with Cash Production	Mainly Commercial
2000	285	211	67	7

SOURCE: MINISTRY OF AGRICULTURE 2001, *COOK ISLANDS 2000 CENSUS OF AGRICULTURE AND FISHERIES.*

Frequently harvested species include parrotfish (pakati), snapper (anga mea), bonefish (kiokio), mullet (kanae), emperors (iroa, mu), shellfish such as, clam (paua), vermetid snail (ungakoa) rough turban snail (ariri), introduced trochus and sea grapes[67] (rimu). Sea grapes are seasonal and are only usually found on reefs flats from March to May before the cooler months. Harvesting and collection of *rimu* is mainly done by women at low tide, then often distributed to relatives or visiting friends. Invertebrate sea cucumbers (rori) that most Aitutakians regard to be important for sand production in the marine ecosystem are also abundant around the shallow part of lagoon.

[64] Adapted from: Saifullah, S. and Mataio, N., (1993). Agriculture in the Cook Islands *New Directions,* pp. 37.

[65] Cook Islands News, Thursday 15 June 2000.

[66] Cook Islands: State of the Environment Report (SOE), 1993.

[67] Clams: *Tridacna sp. Trochus niloticus*, Vermeted: *Serpulorbis*, Sea grapes: *Caulerpa racemosa*,

The Ministry of Marine Resources has improved the island commercial fisheries potential with the introduction of trochus *(Trochus niloticus)*[68]. Although trochus was introduced in Aitutaki back in 1957, commercial exploitation only began in 1981. Ever since, it has proved a popular food source and the lucrative shells shipped overseas provide important earnings for the island communities. After initial uncontrolled harvests drastically reduced populations, Marine Resources now monitors and advises suitable harvest times and quotas, and the community always leaves certain areas un-harvested for stock breeding. The market is operating more effectively after the individual transferable quota system was introduced in 1990. At present the island is sharing the overseas market with Rarotonga, since the Aitutaki quota does not meet the full demand.

Several other fisheries projects have been attempted that were mainly aiming for the Japanese market. For example seaweed (Eucheuma spp.) farming but since Cyclone Sally destroyed the farm in 1987 it has not been re-established. On the other hand, the introduction of Giant Clam could become a success after resolving problems experienced over the years, as in 1993 where some 200,000 juvenile clams were lost due to the station's generator breakdown. Currently, there are three Marine Resources and Fisheries Officers who monitor the two nurseries and all fisheries hatchery processes at Amuri.

The challenge of catching the large hard fighting bonefish attracts several overseas anglers to Aitutaki each year, and is being targeted for tourism promotion. After learning from the success of the ra'ui in Rarotonga improving fish stocks over the past two years, the implementation of the Aitutaki ra'ui is community driven and supported by the Aitutaki Aronga Mana (traditional leaders) with the Island Council. There is hope that these reserves may become more permanent fixtures and allow sustainable fishing in other areas to supply both domestic and Rarotonga markets, as well as satisfying the eco-tourism market.

Surgeonfish (maito), yellow snapper (tangau), and other reef fish A prolonged symptom is a reversal of hot and cold sensations and those affected are unable to eat fish for up to six months after consuming the ciguatoxin. The locals are aware of the problem and move to fishing grounds where poisoning is less prevalent.

Meetings during the 2000 Health Sector Review suggested that more health education was required to encourage those with non-communicable diseases to attend the doctor's clinic. Also, television should be used for health education in schools and villages.

IMMUNIZATION COVERAGE IS EXCELLENT, WITH THE PUBLIC HEALTH NURSES FOLLOWING UP ALL CHILDREN. IN CONJUNCTION WITH THE HEALTH INSPECTOR, THEY UNDERTAKE HEALTH EDUCATION IN SCHOOLS AS WELL AS IMMUNIZATION AND DEWORMING. ANTENATAL COVERAGE IS ALSO VERY GOOD, WITH THE FEMALE DOCTOR TAKING A PERSONAL INTEREST IN ALL CASES.

Table 4: Health Sector Review: Key Health Indicators

Indicator	
Resident Population - 1996	2,272
Resident Population 2000	1,743
Health workers per thousand population	6
Per capita expenditure on health F00/01 ($)	169
Total Number of Deliveries 1998	38
Average monthly admissions 1998	41

[68] Bertram, (1995).

Bed Occupancy %, 1998	39
Average monthly outpatients (1998)	1,289
Monthly average with acute respiratory disease -98	50
Monthly average with skin disease - 98	30
Total number registered with hypertension (80-98)	164
% population with hypertension	11
Current Users - Women on regular F/P contraception-98	290
Has dental worker	Yes
Number patient referrals by sex (Islands to Raro) - 1998:Males	10
Number patient referrals by sex (Islands to Raro) - 1998:Females	18
Has regular rubbish pick up	No
# of private occupied dwellings with W/C or pour flush toilet - 1996	355
Number on destitute or infirm payments at Sep 00 ($100 per mth)	64
Number on aged pension or child benefit Sep 00	623
Total private occupied dwellings -2000	496

Source: Health Sector Review 2000.

- Table 9 Dengue Fever cases in the Cook Islands (by islands)

Island	1991	1995	1996	1997
Rarotonga	641	583	2	1,075
Aitutaki	462	3	-	20
Mangaia	97	2	-	9
Atiu	0	0	-	3
Mauke	49	12	-	27
Pukapuka	0	177	-	2
Manihiki	103	0	-	29
Rakahanga	99	0	-	0
Tongareva	0	2	-	487
TOTAL	1,451	779	2	1,652

- Table 15: Accommodation

Type of Accommodation	Rooms	Beds
HOTELS/RESORTS		
Aitutaki Pearl Beach Resort	37	85

Are Tamanu Beach Hotel	12	24
Pacific Resort Aitutaki	40	80
Sub-total	89	189
SELF CATERING		
Aitutaki Beach Villa	1	3
Aitutaki Lodge	5	18
Gina's Garden Lodges	4	20
Maina Sunset Lodge	12	36
Ranginui Retreat	6	12
Paradise Cove	11	34
Rino's Beach Bungalows	6	18
Sunny Beach Lodge	4	12
The Castle	2	7
Popoara Ocean Breeze Villas	n.a.	n.a.
Aitutaki Seaside Lodges	n.a.	n.a.
Sub-total	42	106
HOSTELS/BUDGET		
Tom's Beach Cottage	8	23
Vaikoa Units	4	10
Paratroopers	8	14
Matrick Lodges	n.a.	n.a.
Josie's Lodge	n.a.	n.a.
Sub-total	29	79
Total	160	375

Source: Tourism Cook Islands.

• Table 10 Aitutaki Tourist Accommodation 1999[69]

Accredited	Total Rooms	Non-Accredited	Total Rooms
Aitutaki Lagoon Resort	30	Tom's Beach Cottages	8
Self Contained		Maina Sunset Resort	12
Aitutaki Lodges	6	Paratroopers	8
Gina's Garden Lodges	4	Paradise Cove Limited	11
Rino's Bungalows	8		

[69] Tourism, 2000.

Budget Sunny Beach Lodge Vaikoa	 4 6		
Subtotal	58		39
TOTAL NUMBER OF ROOMS = 96 15 more rooms currently under construction will be completed by 2001-07-10 Approval has been given for new Pacific Resort Aitutaki to construct 32 rooms			

Physical Attributes of Water Resources

Underground galleries feeding a reticulated system and rainwater catchments are the two main sources of water on the island. Groundwater from bore-holes and traditional wells are infrequently used, and many have been covered up. This is despite the fact that surface water is limited to short-lived rainfall dependent streams and a few small swamps [70]. Spring and well water is readily available on Aitutaki between the depths of 3 metres and 30 metres"[71].

"Fresh groundwater is present on islands because the geologic material acts as a catchment for infiltrated rainwater, delaying its discharge into the surrounding ocean."[72]

The sandy atoll type soils are highly permeable, and any rainfall is rapidly absorbed through fissures in the rocks, seeping down and out to sea. However the remaining volcanic core of the island is relatively impermeable and water runs off down hill to where there is potential to tap them with galleries in a more managed fashion. Research by the AusAid project has shown the ground water capacity of the Vaipeka gallery to be 430,000 litres per day[73]. Figure C -3 in Annex 1 gives an idea of the water resource types that occur on Aitutaki.

The ground water source suffers from salt-water intrusion and has to be supplemented by rainwater catchments and water storage tanks for drinking. The water catchments are seen on Figure 2.7 of Annex 1.

According to locals many of the community rainwater tanks have not been operational for several years. This was due to breaks in the catchment pipe and guttering systems, the rusting of retaining rods, or the tanks themselves. Further tank collapse looks possible with missing and corroding retaining rods and leaks between the pre-cast concrete staves. However, the AusAid Water Upgrade Project cleaned and rejuvenated some tanks, in the hope they will be better maintained in the future. Schools, churches and the hospital have poor or unusable roof catchments, as many of these buildings still have unsuitable and asbestos roofing, and this remains another area to be addressed.

TABLE 2 CAUSE & EFFE CT WATER

Cause	Effect
Technology – more water demanding washing machines, Flush toilets etc	No water for bathing A lot of water wasted compared to hand washing Demand increased relative to pit toilets, use too much water, cistern leaks
Not enough money from Government or Donors	Not enough Money to buy tanks
Increase in developments, hotels, tourists, new houses, private business	Water cuts, main water source run out Population/demand increase No drinking water

[70] Sherwood, A.M. (compiled)., Howorth, R., and Rodda, P. (Edited). (1997). Coastal and Environmental Geoscience Studies of the Southwest Pacific Islands. Technical Bulletin 9. South Pacific Applied Geoscience Commission (SOPAC); pp. 249

[71] Geology of the Cook Islands, by Bruce L.Wood and R..F. Hay, NZ Geological Survey, Universi ty of Auckland 1970, Bullentin N.S. 82, pp.36-40

[72] Buddemeier, 1992:59

[73] Aitutaki Infrastructure Report 1995 Barret Consulting

Sea level rise	Mixing of sea/fresh Salty water
High sea levels, storm surge/ big waves	Less pure water in ground, Not enough fresh drinking water, some crops suffer
Salt water intrusion to galleries (higher sea level, over pumping), Salty and contaminated water	Sticky hair, Soap doesn't lather, Hygiene difficult to wash properly Health Risks, itchy skin, rashes Skin disease etc
SALTINESS	Laundry not clean, Washing machines and appliances rusty, fittings corrode
Over pumping, draining water table, Wells dug by private citizens draining water table	Intrusion of salt water Over-pumping leading to sucking up salt water, Fewer resources to go around
Too many galleries, dependence on mains system	Traditional wells unused, destroyed, not available now
Limited water storage, few community tanks	Not enough tanks to capture rain water for drinking, or to last through a drought
Lack of water tanks	School closures, Children haveNo good water to drink
Lack of tanks	Agriculture crops poor
Drought	Affects agriculture and limited produce for market
Drought	Low pressure, Not suitable for drinking/cooking
No planning/foresight/management	Insufficient catching & storage of water
Lack of and Poor maintenance	Poor quality water for drinking
Maintenance not kept up due to lack of funds	NO PROPER TOOLS FOR TESTING/FIXING
Community tanks not in good condition, not cleaned or maintained	Disease from rusted roofs, Disease carrying insects (mosquitoes) in water, Need to boil/filter/purify
No maintenance of tanks	Rust, Leaking, broken tanks, Pipes, not cleaned
Dirty, No Filter, No water purification, Bacteria	Testing showed some tanks unsafe water quality. Not purified, have to boil, might need to chlorinate, Health no good. Unusable, itchy
Community tank problems (no co-operation to clean, repair)	Time damaged, Less water available, arguments, Politics – not enough tanks
Water tanks not tested	Don't detect Chemical contamination, Bacteria in water tanks, forget to clean
Leakage, Leaky pipes, hoses	High Loss of precious water, Shortage of water no reservoirs
Plumbing problems, Poor drainage	Toilet problems Health – diarrhoea, dysentery, dehydration, Itchy, sore skin, disease
Not recycling water and/or Not using salt water instead of fresh	Houses without water, agriculture uses
Removal of trees	Changes water available from ground

Planters waste water (arrowroot powder)operation	Planters struggle
Waste, Misuse of water Not conserving it	Limited water supply, mains system gets turned off

Table Cause & Effect Health

Health/Mosquitoes/Sandflies	
Bylaw not being enforced, People's attitude	Vacant land Overgrown vegetation Tall bush near homes, rubbish waste Cans, tyres lying around not cleaned away
Manmade Breeding areas for mosquitoes e.g. tins, buckets, tyres	Many Mosquitoes, Nuisance Itchy skin Disturbed/Loss of sleep Have to use sprays, coils, Cost $,
Water tanks not screened, Septic tanks, water runoff channels	Wasting drinking water, has to be boiled filtered, purified
Hygiene/Homes not clean	Filariasis, Dengue fever, Itchy, blood loss, skin infection
Tourism introducing disease carriers	Introduction Spreading of different diseases
Weather changes/patterns rain, humidity etc	Skin Infection, damp led to relocation of houses e.g. Vaipeka
Environment Poor diet, not enough fruit & vegetables	Food/Water poor, contaminated Obesity
Pollution (Air, Soil, Lagoon)	Breathing problems, infections
Lack of medical supply	LIMITED HEALTH DEPARTMENT SERVICE, ILLNESS/DEATH

Table Cause & Effect Agriculture productivity, Fruit seasons

Climate change, seasons shifting, Changeable, less predictable	Too much fruit at once, Fruits rotting before mature, Lifestyle diet changes with less local produce
Too much fruit at once	No resources, skills to preserve fruit/vegies
Salty water from ground and pipes	Plants don't thrive, have to give up growing near beach
Salt water spoiling crops/taro	Few planters to manage land
Dry Land/Soil, Bad/Poor soil, lack of nutrients No virgin soil, white and brown soil do not mix/relate	Land use not suitable, Soil too solid/hard Produces poor quality crops, taro hard to plant – have to change variety from swamp to dryland, mulch or abandon swamps Lack of nutrients in the soil
Drought Less rainfall, El Niño/La Niña	Agriculture crops fail, Spoils the vegetables Not up to standard Less producers/produce Not many people

*too much rainfall rarely mentioned	standard Less producers/produce Not many people planting, Planting produces unhealthy crops, Fires
Too many water holes	Dries up galleries fast/too much draw
No pressure in pipe line Invasive Species -Biological controls	Cannot irrigate, No Money from selling produce It kills/destroys other crops/becomes pests itself
Wandering animals (goats/pigs)	Destroys other peoples garden/crops
Development/Land use Big trees are being bulldozed/cut down, Too much bulldozers tractors	Wasting forestry, Hills are eroding, Roots do not hold soil/water, Loss of topsoil
Removal of Native plants	Other plants not suitable, do not do well
Pesticides, Fertiliser and Chemicals, non organic,	Overuse kills vegetation/soil, lagoon poisoned, Agriculture crops affected Wealthy people can benefit but not small people,
Lack of funding, No government support, No marketing by producers	Do not get right equipment, seeds, advice, Crops do not grow well, No profit

Table Cause & Effect Cyclone/Storm Surge/Erosion

Cyclone/Storm surge/big waves/coastal erosion, cold weather	
Heavy rain	Floods, Crops destroyed, more mosquitoes, Losing land
Strong winds, Hurricanes(cyclones)	Crops and trees like taro breadfruit and banana are damaged, destroyed, Not enough food Shelter and infrastructure destroyed, House damage, house roofs Untidy, mess to clean up, Health, injuries, deaths
BIG WAVES, TSUNAMI	Coastal erosion, land loss Houses are flooded by sea, People have to move inland, erode shore, salt in water/soil ruins growing areas
Pollution	Temperature rising, Global warming
Global warming	Changing climate, Sea Level rise
Sea level rise	Marine life, fishing affected, shrinking land,
Lack of climate change knowledge, early warning	Loss of life
Change of weather pattern	Trees bearing fruit at wrong season
Development on coast	Hotels and jetties and homes damaged by cyclone, Houses near beach collapse
Digging and removal of sand on beaches, Fishing methods, modern e.g. Outboard motors	Eroding shores, no sand to replace

TREES NOT PLANTED ON BEACH SIDES, REMOVING AND CUTTING OF TREES NEAR BEACHES	Less Trees – no replacement, Dirty water, polluted runoff into lagoon, red soil in sand
Don't look after/conserve the land/the sea water Not caring for beach shores, Don't clean around the beach, lazy	Tourists unhappy, Loss of sand/land Beaches are not clean, look messy
No water (drought)	Planters have to work more, less produce
Cyclones	Shortage of the right kinds of food
People'ssins	
Soil Erosion	
Too much digging	Land slides
Bulldozing land	Land loss
Too much tree cutting	No roots to hold the soil
No barriers built on sloping land	Building of new homes
Sand mining/carting away	Greedy for Money
DUST/AIR POLLUTION	Health problem
Increased development	Not enough water
Hotels built on coasts Situation of development	More damage caused by nature/extreme events.

Pollution/Waste septic, chemical, **transport (air)**	
Septic tanks not good standard, leaking, or none at all. No where to process septic waste	Foul smell Bad smell, Health Hazards
NO COLLECTION/STORAG E/PROPER DISPOSAL SYSTEM GARBAGE BUILDING UP, DUMPED ANYWHERE ,NOT ENOUGH DUMP TO PUT AWAY RUBBISH,	People dumping everywhere. Affects drinking water quality. Too smelly/stinks, Poisonous
No where to recycle No recycling system in place, Too much rubbish to cope with	Littering/island looks untidy, Rubbish is thrown around
PEOPLE NOT USING INITIATIVE, TOO LAZY TO CLEAN, TOO DEPENDENT ON OTHERS	Littering, Unhygienic, no recycling
Agriculture activities, chemicals, fertilisers	Runoff to lagoon, Fish Poisoning (ciguatera)
TOO MANY VEHICLES, NOT PROPERLY TUNED	Air pollution, stinky, Diseases health
NOT ENOUGH EDUCATION	Policy not enforced

Coastal Pollution, Dirty Sea, Fishing (seafood resource depletion, fewer crabs, seasons) Poor Reef Lagoon Health, Dying Corals/Clams Coral Bleaching	
Pollution Agriculture Chemicals, Paraquat Chemical runoff from land Dumping rubbish on beach Animals pigs tied near beaches	Seaweeds (waste) floating Kills marine life Pigs waste stinks
Septic, waste, humans and animals in the lagoon Too many snorkellers. People not looking after lagoon Too much drinking alcohol in the ocean	Plastic bags rubbish in lagoon, Ciguatera fish poisoning, can't eat them
Land soil running off into lagoon Too much sand, sediment over coral Too much organic waste (coconut husks)	Fishing areas polluted
Digging along coast eg swimming holes, sand mining Dredging beaches, digging passages	Fish Poisoning
Crown of thorns starfish Too warm Temperature changes	Corals eaten/dying Coral bleaching
Dynamite and poisonous plants killing fish Over fishing Gill nets/too much net fishing Too much fishing for sale Over harvesting crabs (especially females)	Less seafood, clams, fish than in the past. No fish for sale Low Populations No money
More wave surge, tide changes	Lagoon changing, sand moving
Too many outboard engines Boats hitting, anchoring on coral	Polluting/disturbing reef Coral damaged Not enough fish on the reef, compared to

Table Solutions

Water Solutions	Priorities
Rainwater Catchment. Water tanks for each household(10,000Lt, 6000 Lt, 5000Lt, 2000lt.) (build, have enough) More containers for water in each household	Water tank for each household (2000, 5000 litre or 10000 litre) Have enough containers More Containers
Water tanks for community. Government to supply community tanks	Provide water tanks for community * note Vaipeka only village that chose community tanks over household
Boil drinking water Filters at source. Filter for each water tank Purify and filter all water tanks and mains (gallery)water (chlorine?) to keep the water fresh and clean	Purify or filter water
Build quality tanks Professional person to build the tanks locally Proper construction of water tanks	Quality Proper Tanks
Conserve and preserve water Don't leave taps running Don't waste water, Get planters to use less water	Conserve water, bylaws
Education and Awareness program, TV radio, newspaper, pamphlets, educate people to care for water, proper use of water, bylaws.	Awareness Programme
Conserve trees to hold water, Less demand on the land so water for everyone	
Reduce resorts, control developments, tourist accommodation Family planning to lessen population	Hotels and businesses to supply own water systems
Cleanups working bees and weeding by the community around the community tanks Repairs/Maintenance Maintenance of water tanks roofing, spouting Maintain & Care for containers Regular & Frequent Cleaning of tanks & water, Cover top of tanks. Monitoring/screening of water tanks. Regular test of water quality/Bacteria, Clean roofing/spouting, repair	increase availability of plumbing materials Repairs/Maintenance of water tanks roofing, spouting
User Pays, Resorts to pay for the water they use Hotels must have own water system instead of tapping off mains system. Hotels build their own water tanks Monitor hotel/motel use of water, do not turn it off for us and leave it on for them	International Sponsors, More Fundraising
Technology: Desalination, (cloud seeding – too expensive but maybe one day feasible)	Desalination Plant

Improve water supply system Proper drainage, spouting water tanks/containers Proper transport of good drinking water – pipes instead of buckets? Pump to clean water wells, Galleries to be restored again	Hotels to provide own water service
Proper underground water catchment Water galleries Proper piping for distribution of water (materials) throughout villages	Provide Supply water tanks for households Find a way to pay for tanks
Improve Plumbing Service, Educate Plumbers, Proper plumbing facilities. Availability of plumbing materials	Hotels and businesses to have own systems/tanks Desalination Plant
MORE FUNDING/FUNDRAISING/AID TO BUY THE TANKS INTERNATION AL SPONSORS	
Rain dance, prayers	Provide water tanks for households
Use less water demanding flush toilets/washing machines Cut back on flush toilets Lessen use of flush toilet by each household, Decrease pollution of family	Bylaws to look after/conserve the water
Monitor or meter the water levels and usage from the hotels/households tanks. Meter for monitoring off the main road	Maintenance of water tanks
Housing policy that ensures new houses have own water tank New Houses budget for and build their own water tank	Housing Policy, all new houses to have tanks, loan mechanism housing policy each new house must have own water tanks
Supervise/look after the water, Bylaws Policy for water use enforced, Restrictions such as No car and bike washing when water shortage Program of Water quality testing. Test water every 3 months	Policy to be adopted and Enforced

Table 4 Other Sector Solutions

Health Solutions	
Health education Seek advice from health department	
Boil water before drinking	
Eat better – more greens, less tin foods. Avoid drinking and smoking	
Community work, cleaning land around homes Community clean water tanks, supply for the community	Community clean ups of tanks, island, around homes
Agriculture, organic planting	

Recycle cans etc Burn all types of rubbish cars/tyres/etc Collect empty cans and other rubbish/breeding sites	
Improve system of storage, collection, disposal	conserve trees along coast
Water tanks to be screened	
Move to higher area for safety	
Build Sea walls	
Plant trees along beaches to prevent coastal erosion	
Clean the island Vacant homes to be cleaned Clean areas where pigs are fed General cleaning every 3 months Household cleaning	Priorities Identified as: Cleaning up homes (rubbish etc) Survey breeding site to be sprayed Community clean up, working bees
Window door screens Mosquito net Spray (despite chemical pollution)Sand fly breeding site to be sprayed	
3 monthly survey, tutaka	
Hang around with one partner	
Namu Educate mosquito	
Frequent inspections (monthly) Have regular inspection on the island	
Government give fund	
Take mariri (antimalarial)	
Eg Cyclone/Storm Surge – waves/ Coastal Erosion Solutions Tie houses to stop them being carried away	
Move to higher ground (inland)	Priorities Do not cut down trees on coast Do not sand mine/dig holes in lagoon
Do not remove sand from beaches	
Do not cut down big tall trees along coast	
Do not dig holes in the lagoon	

Pollution, waste disposal	
Education	
Collect and destroy crown of thorns	
Chemicals	
Ban tying of pigs, animals along beaches	
Limit septic tanks and look at septic management.	
Stop dumping of rubbish into lagoon	
Outboard motors	
Policy and bylaws to be enforced	
Aid by government	
Prayer	
Ban all agriculture chemicals	
Harvest crown of thorns	
Awareness program on tv radio	
Coral reserve zones Specialists to carry out monitoring program	
Ban fishing by poisoning	
Ban explosives	
Make a law to control reef	
Adopt a beach area/zone	
Coastal Erosion/Big Waves solutions	
Stop feeding pigs along beach (kill and eat pigs!!)	Priorities from above identified Bylaws Plant trees on shore
Policy or bylaws to enforce	
Erect barriers or sea walls	
Those living close to water to move inland	
Conserve coastal trees - pandanus etc Stop removal of sand Do not remove sand from beach	
Plant big trees along coast Plant more trees along coast	

Educate people	
Demand big countries prevent pollution of the atmosphere	
Aid resources More prayers – more humility	
Use of coastal protection units	educate people
Awareness programs	*Priorities from above identified* plant trees on coastal beaches
Policy bylaws	
Pollution, waste disposal, transport	
Dig waste holes for each household	
Burn rubbish	
Have a rubbish drum for each household	
Collect empty tins	
Seek help from Health Department, spray mosquitoes	
Coastal Pollution	
Ban importation of chemicals	
Community working bee	
Planting of big trees on coast	
Beautification along coastal areas	
Ban pigs near beaches	
Enforce policy bylaws in village	
Improve upgrade Reureu beach Seal beach roads	
Sick/Dirty Lagoon	
Ban overwater hotels	
Treatment/Desalinisation plants	
Health education for new households about the sea water	
Remove pigs from beachsides	
Fishing boat pollution	
Patrol of fishing boats quotas	

Collect crown of thorns	
No motorboats waterskiing	
Stop dumping in sea	
Fishing seasons, depletion	
Raui Traditional method of conservation	
Avoid/ban/ Cut down net fishing, bigger gill net holes	
Release baby fish	
Do not use herbal poisons	
Do not leave net overnight	
Do not accept big fishing boats in our ocean	
Export	Priorities include: Enforce bylaws on conservation areas (raui)
Enforce by-laws on fishing	Do not leave nets overnight
Waste	
Incinerator/Rubbish Dump	
Bury empty cans and bottles	
Clean vacant lots	
Have pig sty cleaned Clean out septic tanks	
Waste disposal, do not litter	
Introduce recycling plant	
Drums on sides of roads	
Awareness program	
Contractors for carting rubbish	
Policy By-Laws	
Land use, soil erosion /cutting trees solutions	
Planting trees on slope sides	
Ban bulldozing/cutting big trees	
Awareness program in schools	
No carting of soil/sand Introduce environment act	
Body created to monitor tree cutting/house building	

Organic growing	
Crop rotation	
Land use, Development	
Leave good trees only cut certain trees down	
Less hotel building	
Don't dig soil	
Conserve	
Agriculture, Fruit Seasons solutions	
Educate people in use of chemicals	
Encourage children to be interested in agriculture	
Focus on food crops not marijuana	
Weed manually instead of using herbicide	
Do not burn vacant lands	
Do not import chemicals/go organic	
Ban importing of overseas plants/flowers – quarantine controls	
Agriculture Land use, /cutting trees solutions	
Ban use of chemicals	
Educate growers and everyb ody	
Use organic system	
Bring technical resource people	
Workshop awareness	
Observe national days e.g. world food day Aitutaki	
Conserve nature, trees	
No burning	
Eat leafy diets/foods	
Agriculture Seasons, Drought Productivity	
Ban all chemicals	
Ban importation of species that may be invasive	
Organic farming	
Plant more trees on hills to prevent erosion	

Stop use of bulldozers	
Awareness program/workshops	
Use traditional planting methods such as ara po (by the moon) Education	
Don't cut big trees	
Pray to god	
Plant our own veggies, increase the number of growers.	
Do not burn rubbish leave it for manure/compost – Solution	