Addressing Climate Change and Sea Level Rise in the Pacific Islands

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Climate Changes and Globalization －Environment and People's Life in the Pacific Islands－

Addressing Climate Change and Sea Level Rise in the Pacific Islands

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Abstract

Climate change and sea level rise are no longer a future phenomenon; they are taking place now and require more concerted effort. The situation in the Pacific Islands is even more serious because even though these small islands have done little to cause the problem and can do little to address it, they will be the first victims. Furthermore, the options for these islands are restricted by their small sizes and lack of resources.

However, Pacific Islanders have extensive experience living in these small islands for generations and can offer worthwhile lessons on how to address climate change and sea level rise. In this paper, we examine some options for addressing the phenomenon in the Pacific Islands.

A strategy for addressing the challenges of living in a world affected by climate change and sea level rise will be unveiled. As always, innovation and good plans and strategies will influence in the ability of Pacific Islands to address this problem. Addressing climate change and sea level rise in the Pacific Islands, has to be appropriate for these islands, which means that the solution has to be found from within the small islands. Some areas where changes can be considered include appropriate coastal protection, adaptation in land use and living practices and new options such as aquaculture, sustainable living at community level and new crops and varieties.
Keywords: coastal protection, community, customary practices, good plans, innovation, land loss

要　旨

気候変化や海面上昇はもはや未来の出来事ではない．それらの現象は現実に起こりつつあり，その解決のためには人々のさらなる協力が必要とされている．太平洋の島々は，これら気候の変化や海面上昇の原因としてはほとんど無関係であるにもかかわらず，より深刻な影響を受けている．また，これらの現象に対する備えもほとんどないため，その最初の被害者となろうとしている．さらに言えば，これらの島々は小さく，また，資源もほとんどないため，その対策もほとんど限られている．

しかし，これら小さな島々に住む人々は，長い世代に渡って蓄積された豊富な経験を持っており，気候の変化や海面上昇などの問題の解決のための何らかの有効な答えを発見できると思われる．この講演では，これらの現象への備えとして，いくつかの解決策について検討したい．

まず，気候の変化や海面上昇が起こる世界で生き抜いていくための戦略について検討したい．革新的な方法や計画，戦略は，これらの現象に対処する人々の能力にも影響を与えると思われる．気候の変化や海面上昇に備えるための戦略は，これらの島々にとって適切なものでなければならず，すなわち，解決策はこれら小さな島々から生み出されてくるものでなければならない．具体的な方法としては，海岸線の防護や土地の利用法，生活様式，水産業などの改良，あるいはコミュニティレベルにおける持続的生活様式や新しい作物あるいは品種等の導入などが考えられる．

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Introduction

The Pacific Islands cover an area of about 30 million km^2 of the world's largest ocean. The islands are small but there is also great geographic, demographic and developmental diversity (SOUTH *et al*. 2004). Detailed descriptions of the islands are provided in Annex 1. Differences in climate, geological resources, topographical features, soil types, mineral and water availability, extent of coral reefs and diversity of terrestrial, freshwater and marine flora and fauna are also features of the region.

Although some of the larger island groups have significant mineral, forestry, fisheries and agricultural land resources, most Pacific Island states and territories and smaller outer islands and isolated rural communities do not. The options for economic development are thus extremely limited.

Climate change and sea level rise are now global phenomenon. The IPCC Third Assessment reports and the recently released Fourth Assessment reports outline what is to be expected by 2100 with the only uncertainty relating to the timing and magnitude of the changes; not its occurrence (IPCC 2007). In the Pacific Islands these events are already evident through coastal flooding, erosion, salt water intrusion into ground water sources and increased storm damages. In addition, the countries of the region are also under threat from their rapidly increasing population that needs settlements and the necessary facilities. These events make it critical that Pacific Islands devote more concerted effort to address these eventualities.

It is ironic that the Pacific Islands are required to commit resources they do not even have to address climate change and sea level rise because these small islands have done little to cause the problem and can do little to address it. However, unlike the industrialized countries that have response and adaptation options, these countries will be the worst victims. While the industrialized countries ponder over their loss of employment and of industries, Pacific Islands will be considering emigration and resettlement abroad in foreign land.

However, there is hope. Pacific Islanders have extensive experience living in these small islands for generations and have traditional knowledge and wisdom that can be the basis of response and adaptation policies, strategies and actions to address climate change and sea level rise issues (VEITAYAKI 2002). In this presentation, we examine some options for addressing the phenomenon in the Pacific Islands.

The region needs to pool its resources and expertise to map a regional strategy for addressing the challenges of living in a world affected by climate change and sea level rise. This will require innovations, good planning and the involvement of all stakeholders. Pacific Islands will need to forge partnerships and collaboration locally and internationally. Climate change and sea level rise responses and adaptations in the Pacific Islands have to be appropriate for these islands. There cannot be too much of the high-tech and costly solutions but those that are cost effective and proven. Some areas where changes can be considered include appropriate coastal protection, adaptation in land use and living practices and new options such as aquaculture, sustainable living at community level and new crop varieties.

There are four other sections to the paper. The first is an overview of the Pacific Islands, which highlight some of the features of life that will be influential to the options and choices that are available. The second section examines some of the issues that are relevant to addressing climate change and sea level rise. The third section introduces the policies strategies and actions that Pacific Islands can adopt to address the problems of climate change and sea

level rise while there will be reflections on the future as the concluding remark.

Pacific Islands

The Pacific Islands are dominated by the ocean, which has social, spiritual, cultural and ever increasingly, economic significance (Fig. 1). Land accounts for only 2 percent of the region's total area of approximately 550,000 km^2. The largest of the islands is Papua New Guinea (PNG) with 84 percent of the region's land area. Seven islands have land areas of over 700 km^2 while four have less then 30 km^2 each. Fifteen territories are either made up wholly atolls or largely of atolls and coral islands. Others, with the exception of Samoa, have a combination of both high volcanic islands and low atolls (SOUTH *et al*. 2004).

The scarcity of land-based resources in many Pacific Islands particularly in the atoll countries and territories has meant that the focus in recent times is directed to the resources of the oceans to sustain livelihoods. This same focus has grown in importance over the years to the point where it has become necessary to put in place management structures to attempt to monitor and control the increasing demand placed on the ocean's resources.

According to SPC's estimates (HABERKORN 2004), the population of the Pacific Islands reached 8.6 million in 2004, representing an increase of approximately 1.7 million people over the past 10 years. The five largest island countries and territories (those comprising Melanesia) account for the vast majority (86.4%) of the regional population, followed by the much smaller island countries and territories of Polynesia (7.4%) and Micronesia (6.2%). With an annual population growth rate of 2.2 % per annum; there will be a doubling of the Pacific Island population in 32 years.

Half of the 22 Pacific Island countries already have a larger proportion of their population living in urban rather than rural areas. With an annual urban growth rates of between 3 and 4 per cent, population doubling times range from 17 to 23 years. In South Tarawa, for instance, with its current estimated growth rate of 5.2 % per annum, the population will double in just 13 years. Given the enormous population-resource pressures at present, it is inconceivable to see how South Tarawa's economy, its society and environment will be able to cope with an additional 36,700 people in nine years (HABERKORN 2004). Already the population density in cities such as Funafuti, Tarawa and Majuro rival those in Hong Kong and other densely populated cities in Asia.

Important social and economic issues in the region include high population growth rates, slow economic growth rates, urban drift, breakdown of traditional lifestyles, a strong dependence on aid, increasing poverty and the rapid adoption of the cash economy. Political instability has also figured prominently in recent year as exemplified by the current situation in Solomon Islands, Fiji, French Polynesia and Tonga.

Loss of land is a major concern throughout the Pacific Islands. Even for the higher and larger island, the loss of land associated with any increase in sea level will be devastating in the coastal areas. In the atolls, where the average height of the landmass is less than 5 m, the loss of land or whole islands will mean catastrophic changes. At the moment, the effects of higher sea level are evident in cultural sites such as burial grounds.

In Tuvalu, some of the graves have been washed away and there was one occasion when the coffin started to float to the surface due to high tide before it was buried. In some of the countries, cremation is now being done but the acceptance of this practice is not easy to promote

in some of the Pacific Islands. "I had difficulty putting this idea across to the elders in Tuvalu when I conducted a workshop on community empowerment and mobilization" (Alan Resture per.com 7th Feb, 2007).

The implications of loss of territory and island for Pacific Islands are immense. The loss of territory and island will diminish areas under national jurisdiction and impact heavily, among other things, on economic and subsistence needs of island nations. The sale of licenses in the Kiribati EEZ was worth $A29.4 million some years ago and was one of the main source of foreign exchange (BOROVNIK 2006). In all Pacific Islands, local communities have traditional, cultural and spiritual attachments to the sea, particular species, reefs, islands and natural formations. This will make the disappearance of territory and island significant. It can also influence the demarcation of maritime boundaries.

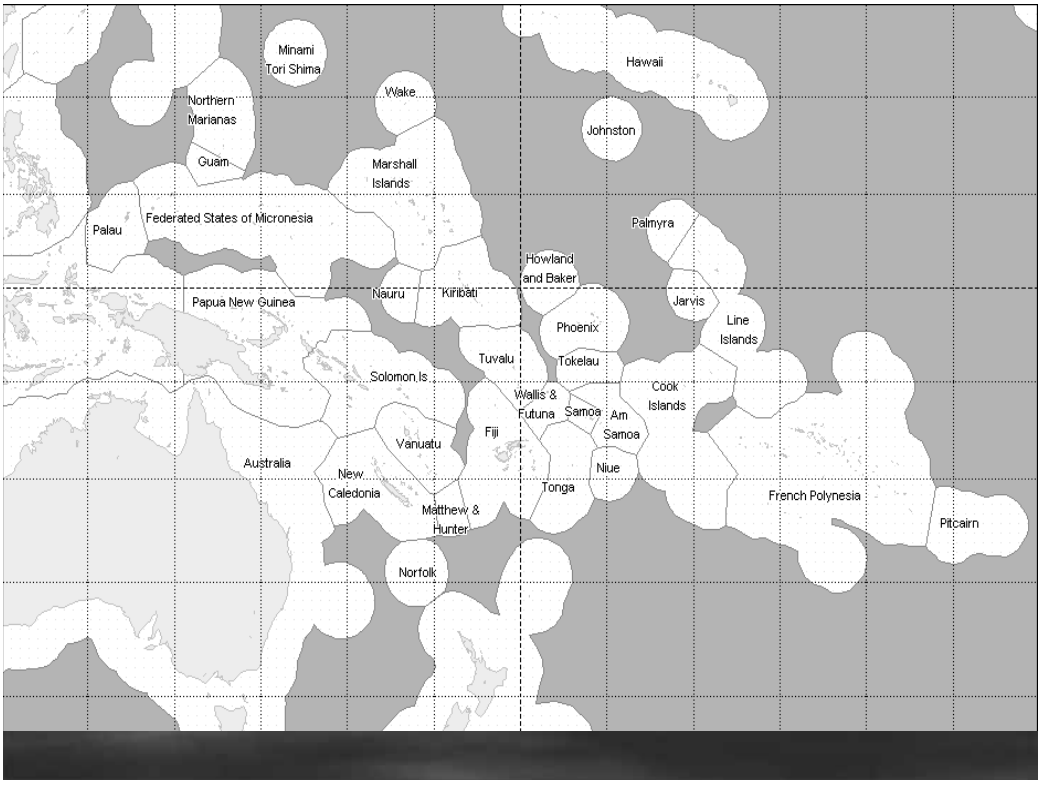

Fig. 1. Pacific Island showing their EEZ boundaries.

Issues Relating to Climate Change and Sea Level Rise Issues

Pacific Islands are highly vulnerable to climate and sea level changes and have a large natural resilience that is increasingly impaired by human pressures. Some of the issues relating to climate change and sea level rise that are considered critical in the Pacific Islands are examined to show the nature of these issues, the attempts undertaken within the region to address these and the challenges that have to be addressed and overcome to secure the lives of the people and communities in these islands. The examination should also highlight the policies,

strategies and actions that have to be undertaken to address the issues. The issues discussed here reiterate some of those that were raised by Seremaia TUQIRI (2001) as background to the Pacific Islands Regional Ocean Policy conference.

Climate change and sea level rise related issues are widespread in the region but are regarded differently by each state and territory, which have its own set of priorities, strategies, and responses to the different issues. The Pacific Islands are vulnerable to the effects of climate change and sea level rise but the atolls and coastal and low lying areas are most at risk. Many coral atolls do not rise over 5 m above sea level and could become uninhabitable due to inundation, which could be caused by natural as well as human activities. The challenge for the Pacific Islands is to design and institute disaster management plan at the regional, national, district and local levels.

The impacts of climate change will affect all sectors of the economy in the Pacific Islands. It is expected that changes will occur in rainfall patterns and soil moisture, prevailing winds and short-term variations in regional and local sea levels and wave action patterns. The only uncertainty at the moment will be the duration and the magnitude of the changes. Potential impacts are also expected in the distribution and abundance of offshore fish, productivity of inshore fisheries and fish breeding sites, marine ecosystems and more extreme weather patterns. Coral bleaching are expected to increase and to negatively affect the coral reefs while the health and distribution of mangroves and sea grasses beds are also expected to be affected. This is why the Pacific Islands need to address the issues of global warming at the local, national, regional and international levels.

Pacific Islands and their regional organizations had demonstrated great commitment in undertaking proactive actions to address the effects of climate change. Most countries have ratified the UN Framework Convention on Climate Change 1992 (UNFCCC) and are attempting to identify relevant cause of action to combat the impacts of this global phenomenon. Regional initiatives like the National Environment Management Strategies (NEMS) have focused on policies and strategies for climate change and sea level rise and promoted integrated coastal management plans but these need to be implemented. The Pacific Islands Climate Change Assistance Program (PICCAP) assisted countries with their reporting obligations under the UNFCCC.

Any change in sea level is expected to affect the claims by coastal states that have declared extensions of their maritime zones. The extension of maritime boundaries is crucial for Pacific Islands because of the development prospects of both living and non-living resources. Maritime boundary delimitation is a sovereign responsibility under the United Nations Convention on the Law of the Sea. Pacific Islands have all declared their maritime boundaries; some reference points for which are based on some very low islands and reefs. Some of the boundaries still need to be formalized. Furthermore, 45 common boundaries between Pacific Islands need to be finalized while countries such as the Federated States of Micronesia, Papua New Guinea, Fiji, Solomon Islands and Tonga need to claim continental shelf extensions. For this to happen, these Pacific Islands need to conduct research and field surveys to prove that they have continental shelves. The maritime area claims can be altered greatly if the baselines are altered because of sea level changes.

Numerous islands claimed by Pacific Islands are in remote areas and are uninhabited. For example, in the Phoenix Group in the Republic of Kiribati, only one island (KANTON Island) is inhabited while the rest are uninhabited. While some of other islands in the group were

inhabited in the past for at least two years, the main reason for the departure of the inhabitants is the unavailability of potable water.

The loss of island territory because of storm surges and sea-level rise is a real threat to claims and existing maritime jurisdiction of Pacific Island. Can traditional, cultural and spiritual attachments validate and affirm a coastal States claim over remote islands or natural formations? Are these attachments enough on their own? The shift from Island to Non-Island status (and *vice versa*) is not adequately addressed in international law. Where territory is submerged, what happens to existing maritime boundaries? Can the claim over existing maritime boundaries stand despite the loss of island territory used as a baseline for delimitation? Can there be special dispensation/exemptions granted for island States in this predicament? Should the special dispensation account for the geological composition of small islands and atolls and their vulnerability to the effects of sea-level rise? These are interesting and relevant questions that need to be addressed through good research.

Where an island is severely impacted by climate change, there will be an inclination by Pacific Islands to reconstruct islands with the use of sand, coral, rocks or other material. For small low islands and atolls built from coral or limestone, materials used would be limited to what is available. Would this activity be considered reinforcement or the construction of an artificial island? Would the situation be different if there was a pre-existing island which was lost by sea-level rise or wave action?

Marine scientific research (MSR) is crucial in determining the impacts of climate change and sea level rise as well as the options available for local preventative and adoptive measures. Marine scientific research is the responsibility of coastal states that can determine not only the seabed mining and marine resource sustainability issues but also the other potential uses of marine resources. Pacific Islands, however, have little or no MSR capability and rely heavily on regional organizations such as the Pacific Islands Forum Fisheries Agency (FFA), South Pacific Applied Geoscience Commission (SOPAC), University of the South Pacific (USP), Pacific Regional Environment Program (SPREP) and Secretariat of the Pacific Community (SPC) and competent international research organizations. Marine scientific research can provide information vital for addressing the impacts of climate change and sea level rise.

SOPAC leads the delimitation of maritime boundaries and is the depository for data obtained from research conducted on coastal processes; coastal, nearshore and offshore minerals, hydrocarbon and wave energy potential, and marine geology and geophysics. The SPC conducts long term scientific research and monitoring of the fisheries, assessment of stocks, data collection, synthesis and analysis and advice member countries on the management and development of oceanic and coastal fisheries at national, regional and international levels. The USP conducts applied research and training on mariculture, aquaculture, post harvest fisheries and marine resources management.

Discoveries of cobalt-rich manganese nodules within the EEZ of the Cook Islands; cobalt rich crust within FSM, Marshall Islands, Kiribati and Tuvalu; and gold-bearing sulphide deposits on the seafloors of Fiji, Tonga and PNG provide new opportunities for Pacific Islands. However, few nations have formulated policies and legislation on offshore mineral development and need to ensure that their marine environment is not destroyed if seabed mining is undertaken.

At the moment, the blasting and dredging of coral reefs and mining of coral aggregate are common in Pacific Islands where they cause serious impacts. Coastal mining in the Pacific

Islands is serious providing in some cases the only sources of construction materials in countries such as the FSM, Fiji, Kiribati, Marshall Islands, Tonga, Tuvalu, and Samoa. Dredging is done in rivers, beaches and shallow coastal waters while individuals often mine the beaches for sand and aggregates for their domestic use. In Fiji, an extensive dredging program has been undertaken to deepen the rivers and reduce flooding in the river mouths. The dredging has been associated with the loss of wetlands and the destruction of marine fisheries that the villagers rely on for food and income.

The degradation of reefs and erosion of coastal areas are prevalent in the Pacific Islands. About 41 percent of the reefs in the Pacific are under medium to high pressure from human development. The destruction of coastal ecosystems such as coral reefs, mangrove forests and sea grass beds are associated with beach and coastal mining, construction of coastal structures, land-based and marine-based pollution, fishing, natural disasters and poor development planning. The implications for Pacific Islands suggests a need to study natural systems, examine the response of nearshore systems to any sea-level change, develop appropriate coastal protection systems, and formulate policy on accommodation and adaptation options.

Increased population for most Pacific Islands and coastal developments such as infrastructure, coastal settlements and coastal development contribute to serious coastal problems. With urban centers such as South Tarawa, Majuro, Funafuti, Nukualofa and Suva having very high populations for their sizes, the pressures on coastal environment and resources worsens. In fact, most of the ports in the Pacific Islands are badly polluted.

The use of pit latrines in some of the urban centers such as Funafuti and Tarawa will cause problems because eventually new pits will be required. Where land is limited, this may become a major constraint. In addition, septic tanks in atoll environments, especially in built-up areas, perform less effectively than in other places because effluent drainage lines are short due to small allotment sizes, and the nature of the soil combined with a high water table means that nutrient-rich waste quickly enters the groundwater. In addition, sludge from septic tanks must be pumped out periodically while suitable treatment and disposal arrangements are not currently available (RESTURE 2006).

Training, education, and public awareness are cross cutting issues and are conducted at different levels by all of the regional organizations. The USP is responsible for formal training but applied research is also conducted by other technical regional organisation. The management of data is also critical for the sharing of experience that is needed. The Pacific Islands Marine Resources Information System (PIMRIS) provides assistance for accessing data within the region. Research information from Pacific Islands is shared to facilitate their use by others.

Response and Adaptations

Pacific Islands, with their financially weak economies and lack of resources, need to design responses and adaptations that are appropriate for their people. It is therefore not wise and practical to have high-tech and expensive responses and action. On the other hand, Pacific Islands can utilize their traditional knowledge and customs to organize themselves and be prepared for the impacts of climate change and sea level rise. The important thing is for the people to undertake individual activities that are required to ensure the communities cope with the changed environment associated with the altered conditions.

Pacific Islands need to have the best climate change and sea level related information on

their islands. These can be done by collating relevant information from different parts of the country and setting up an institution to coordinate the response and adaptation to climate change and sea level rise. The information should enable the individual countries to better understand how different areas will be affected by the changing climate and sea levels. Simulations and various scenarios can be applied to explore anticipated impacts. The information should aid in planning and decision making on emergency evacuation plans and centers.

Pacific Islands need to consider undertaking the following activities:

- gathering and improving information on the impacts of climate change and sea level rise on all human and natural systems in the islands
- building capacity in specific areas by collaborating with other organisations and institutions
- developing strategies for responses and adaptation using traditional and appropriate contemporary methods
- ratifying climate-related instruments and incorporating these into national legislation
- promoting awareness programs on useful lessons
- fostering collaborations with developed and industrialized countries
- improving early warning systems and back-up facilities to reduce vulnerability and improve response time
- encouraging appropriate reforms in the policies and measures to reduce greenhouse gas emissions
- promoting clean development technology.

The response strategies available to Pacific Islands come under three major categories: retreat, accommodation and protection and enhancement. Retreat means the abandonment of the vulnerable areas and the relocation of the activities to planned sites away from these areas. The major challenge with this option is the lack of land so the response can be implemented only in the larger islands. Moreover, the ownership of land will hinder relocation of some coastal communities as the less vulnerable areas will be owned by other groups. In the atolls, this option is not likely to be used.

RESTURE (2006) described the magnitude of the problem in Tuvalu. He noted that almost 4,000 people or 43 percent of the total population are squeezed into the main islet of Fogafale, Funafuti, which has an area of only 2.79 km^2. A third of the total land area is uninhabitable because it is used as the airfield or the excavated borrow pits that were used in the construction of the airport. Even with the land area of 2.79 km^2, the population of 4,900 (in 1996) on Funafuti results in a population density of 2,634/km^2. The density, which is higher than this amount if the uninhabitable area is taken into consideration places tremendous pressure on government resources.

Fisheries are the main source of protein in the diet of Tuvaluans. According to an ADB (1994) survey, each person eats about 500 grams of fish per day; which is equal to 2,000 kg/day or 730 t/year across the population of Funafuti. With this type of demand, there is little hope of the environment keeping up, which means that the supplies have to be brought in from other areas.

Tuvalu has secured an agreement with New Zealand (under the Pacific Access Category and the Temporary Labor Scheme) for the resettlement of 75 of her citizens to New Zealand each year. A similar application to Australia has been refused. In Tonga, PERMINOW (1993)

reported the internal movement of people into Kotu because of better opportunities compared to all its neighboring islands. Similar resettlement took place in Papua New Guinea (ALLEN *et al*. 1993). In both cases, there were some social and cultural relations that allowed for these resettlements. Resettlements will be the main option if life as currently undertaken is no longer possible in the islands and there need to be social and cultural arrangements made for this eventuality.

Accommodation is a where the alteration is made to the use of the area but the people continue their activities in the area. This is a more appropriate option in the major centres in small atolls. In Tuvalu, houses on piles are now built in the water-covered "borrow" pits (Fig. 1). Similarly, the Marine Studies Facilities at the USP is designed to allow water to flow underneath without causing too much problems (Fig. 2). Pacific Islands should encourage changes in the design of building, building standards and other measures to accommodate the expected changes. There must be evacuation and emergency plans and shelters that people are made to know. The governments may also set up insurance and other incentives to encourage people to take the risk of establishing their operations in the vulnerable areas.

In addition, new activities that are considered more appropriate given the expected changes must be pursued. Identification of drought and salt tolerant crops or even newer uses of resources such as mariculture and marine-based ecotourism can be considered. People may consider riding bicycles and motor bikes instead of cars and trucks which would reduce the need for roads.

Fig. 1. (top left) House in flooded borrow in Funafuti.
Fig. 2. (top right) Building for change, Marine Studies Facilities, USP.
Fig. 3. (bottom left) Coastal protection built by Naovuka Villagers.
Fig. 4. (bottom right) Rehabilitated coastal habitats provide shelter in Nacavanadi Village.

Fig. 5. Rehabilitated mangroves in Malawai Village.

The production of new commodities such as the coconut furniture and products can provide excellent opportunities in the Pacific Islands. More attention should be devoted to new technology that will enhance the health of the environment. Compost toilets, smokeless stoves and fish aggregation devices are all examples of technology that can reduce human impact on the island environment. Other technologies such as the use of renewable energy and the management of waste can ensure the maintenance of the health of the environment that will in turn protect and provide for communities.

The third and last response strategy is to protect and enhance the known vulnerable areas. Protection and enhancement can come in terms of hard structure such as seawalls, dikes, groins, flood gates, tidal barriers and detached breakwaters or soft structures such as beach filing, beach nourishment and the maintenance of healthy and vibrant ecological systems such as coral reefs, sea grass beds, mangrove forests and wetlands. The hard structures as those used in Japan are effective but expensive and out of the reach of Pacific Islands. Hard structures also change the nature of coastal processes and often have to be used around the whole island. On Nukufetau, Tuvalu for example, the construction of seawall on one end of the island eroded the other end completely. The construction of the causeway on Tarawa, Kiribati interfered with the natural flow of currents and was blamed for the disappearance of Bikenman, an islet opposite the causeway. In the Pacific Islands, the absences of continental shelves make the task of protecting the coast difficult. In many cases, the protections have to be built on the reefs, which is not very healthy. In other places, the depths outside the reefs forbid any kind of construction that can withstand strong wave and wind actions. Furthermore, there is a lack of building materials like sand and gravel, which add to the expenses. On the other hand, soft structure can be undertaken with minimal costs if people undertake to look after their natural environment so that these are healthy and capable of providing the services that they normally provide.

Adaptation options also must be appropriate for Pacific Islands. This is where the use of traditional knowledge and practices can help. Pacific Islanders own their coastal resources and can make difficult decisions about their resources if they are convinced of the reasoning behind the actions that they are to take. In the work of the local communities to manage their fisheries resources in the Solomon Islands, Vanuatu, Papua New Guinea, Cook Islands, Samoa and Fiji, the people have demonstrated their commitment to undertaking resource management activities when they are convinced that these actions are necessary. Villagers in Vanuaso Tikina in Fiji are already trying to address these issues as part of their resource management activities (Fig. 3, 4 and 5). The villagers are aware that there own survival is threatened if the resources that they depend on are under threat.

Traditional resource conservation used by the Tuvaluans include restrictions on the type of fishing gear used, and prohibitions on fishing by villagers during the spawning run of flying fish, bonefish and mullet. Mulching was used extensively for subsistence farming, and many of the

trees with cultural and utilitarian values were protected. On the island of Nukufetau, the island elders have the final say in deciding when to harvest giant clams and the size restrictions (RESTURE 2006).

Public education and awareness are necessary to promote the need for adaptation to the impacts of climate change and sea level rise. With the increasing information and case studies becoming available, the lessons should be evident. These knowledge and practices should be publicised widely to all parts of the region. Individual countries need not start from scratch. There are enough lessons to learn from to allow the countries to decide on the response and adaptation strategies and action that best suit them.

Pacific Islands can meet their obligations to undertake marine scientific research through joint research and site visits with regional and international research institutions. This arrangement can provide Pacific Islands access to technology and expertise as well as opportunities for funding and the sharing of experiences and capacity. To be effective at this, Pacific Islands need to be ready to collaborate with competent research partners. As a first step, Pacific Islands need to seriously observe the implementation international conventions and treaties that they have agreed to. These international agreements should now be enforced in all the countries across the region. Individual countries need to demonstrate commitment to their collective agreements. Regional agreements need to be ratified and implemented by the countries, which in turn, should translate these to local community actions.

Future

The Pacific Islands are now at the cross road. There homes are under threat from changes associated with climate change and sea level rise. The islands biggest resource, its people, should now be mobilized to prepare for the eventualities. Pacific Island need to act individually and collectively to address the problems at all levels of society. The people today have the opportunity to shape the future of life in the islands and they should do it properly while they have the time.

All Pacific Islands have ratified the Kyoto Protocol while the industrialized countries have not made much progress. There is little to do expect to appeal to the big countries to do the right thing. One lesson, that should now be clear to all is that what ever is done to the environment will be reflected in its service to humanity. Humanity cannot be independent of the environment and must do all in its power to ensure that it leaves within the bounds and limit posed by the natural systems.

The challenge in many Pacific Islands would be to secure adequate funds to enable adaptation and protection and enhancement. Marine scientific research will be required to provide the necessary information. Given the high costs, Pacific Islands need to be innovative in how they address this international obligation. There are avenues to foster equitable collaboration with competent international organizations. The countries should design arrangements that will allow them to benefit from collaboration with developed countries partners.

The proposed research on Okinotorishima by Japan is relevant to Pacific Islands. If corals can be grown to enhance the small islands and coastal areas as the Japanese scientists are proposing, the impacts in the Pacific Islands would be huge. Research is needed on the

reinforcement of islands and natural formations claimed by coastal states. For Pacific Islands sea-level rise and the loss of coastal areas within the region are very real and likely issues. Should Small Islands Developing States vulnerable to sea-level rise and other human induced or natural phenomena be permitted to reinforce their islands? In the cases of Pacific Islands, this option may attract a great deal of attention given the use of many small islands for settlements, coastal development and baseline references. The research will offer new hope to the Pacific Island and boost their resolve to maintain their communities in these islands. Of course, closer collaboration with Japan and other countries will be a necessary first step to benefiting from this possibility.

Developing new technologies and alternatives would require good research programs that many of the countries do not have. This has to be addressed because a lot more benefit will accrue from good research programs that are forward looking and innovative. Salt resistant crops, new uses of existing resources and new resources can all be obtained through good research and can be sources of new opportunities in Pacific Islands. It is also important to remember that international collaboration with local flavor will be the most appropriate option.

Development policies and adaptation approaches must emphasize proactive, anticipatory plans, projects and programs. The viability of long-term investments in infrastructure and development activities must focus on the sensitivity of projects to the effects of climate change and sea level rise. Large scale projects must have an EIA, which should determine the suitability of the project. There are ample examples today where after having made the development and knowing the results and the impacts, the countries involved are not so sure about having made the right choices. Coastal protection needs to be thoroughly assessed for its possible adverse effects. In a number of cases such as with the construction of seawalls, the adaptive measures may have been more destructive because of effects on tempering of the dynamics of the coastal processes.

This is why the Madang Guidelines suggest that Pacific Islands have marine mineral development policy that is sensitive to fisheries development. The biologically diverse nature of the fishery, its wide coverage of the marine environment and the impact marine mining can have on a wide range of fishing operations ranging from subsistence fishers to purse seiners must be recognized.

Development of national expertise in specific areas should be encouraged to support ongoing research and experimental work. Capacity building and institutional development should be ongoing with follow-up programs. Pacific Islands need to promote the conduct of foreign MSR in their waters, improve their own scientific capabilities and use the assistance of regional organizations.

Climate change and sea level rise are no longer the questions. Recent events and evidence point to their eventuality. The question now is how well prepared Pacific Islands will be living in a world affected by these global changes. Pacific Islands have existed for thousands of years and must be allowed to be part of the new world.

Appendix I. Summary Data on Pacific Islands

American Samoa
Capital: Pagopago
Population: 57,790 (2006 est.)
Land area: 200 km^2
Max height (above sea-level): 966 m (Lata)
Rainfall:
EEZ: 390,000 km^2
Mean temperature: 30.9 ºC (87.7 ºF)
GDP per capita: US$ 5,800 (2005 est.)

Cook Islands
Capital: Rarotonga
Population: 21,390 (2006 est.)
Land area: 236.7 km^2
Max height above sea-level: 652 m (Te Manga)
EEZ: 1.8 million km^2
Rainfall: average of 2,040 mm per annum
Mean temperature: 24℃
GDP per capita: US$ 9,100 (2005 est.)

Federated States of Micronesia
Capital: Pohnpei
Population: 108,000 (2006 est.)
Land area: 702 km^2
Max height (above sea-level): 791 m (Dolohmwar)
EEZ: 2,978,000 km^2
Rainfall: Rainfall is high, varying from about 3,000 mm on drier islands to over 10,000 mm per annum in Pohnpei
Mean temperature: 27℃
GDP per capita: US$ 2,300 (2005 est.)

Fiji
Capital: Suva
Population: 905,950 (2006 est.)
Land area: 18,272 km^2
Max height above sea-level: 1,324 m (Tomani-ivi)
EEZ: 1.26 million km^2
Rainfall: Rainfall is highly variable and mainly orographic (influenced by the island topography and the prevailing south-east trades).
Mean temperature: 28℃
GDP per capita: US$ 6,100 (2006 est.)

French Polynesia
Capital: Papeete
Population: 274,580 (2006 est.)
Land area: 4,167 km^2
Max height above sea-level: 2,241 m (Mont Orohena)
EEZ:
Rainfall:
Mean temperature:
GDP per capita: US$ 17,500 (2003 est.)

Guam (USA)
Capital: Agana
Population: 171,020 (2006 est.)
Land area: 541 km^2
Max height (above sea-level): 406 m (Mt. Lamlam)
Rainfall: Annual rainfall varies from 2000 mm to 2500 mm
EEZ: 218,000 km^2
Mean temperature: 27ºC (81ºF)
GDP per capita: US$ 15,000 (2005 est.)

Kiribati
Capital: Tarawa
Population: 105,430 (2006 est.)
Land area: 811 km^2
Max height (above sea-level): 87 m (Banaba)
Rainfall:
EEZ: 3.6 million km^2
Mean temperature: 29℃
GDP per capita: US$ 2,700 (2004 est.)

Republic of Marshall Islands
Capital: Majuro
Population: 60,420 (2006 est.)
Land area: 181.3 km^2
Max height (above Sea-level): 10 m (Likiep)
EEZ: 2,131,000 km^2
Rainfall: Varies from north to south; Ujelang has an average of 2,030 mm per annum while Jaluit, further south, has twice that amount.
Mean temperature: 27℃
GDP per capita: US$ 2,900 (2005 est.)

Nauru
Capital: Yaren District
Population: 13,050 (2005 est.)
Land area: 21 km^2

Max height (above sea-level): 70 m (location along plateau ring)
Rainfall:
EEZ: 320,000 km^2
Mean temperature: 29ºC
GDP per capita: US$ 5,000 (2005 est.)

New Caledonia
Capital: Noumea
Population: 219,250 (2006 est.)
Land area: 18,576㎢
Max height (above sea-level): 1,628 m (Mt. Panie)
EEZ: 1,740,000㎢
Rainfall: Varies from 2,000 mm in the east to 1,000 mm in the west per annum
Mean temperature: 23℃
GDP per capita: US$ 15,000 (2003 est.)

Niue
Capital: Alofi
Population: 2,170 (2006 est.)
Land area: 259 km^2
Max height above sea-level: 68 m (near Mutalau settlement)
Climate: Tropical; modified by southeast trade winds
Rainfall: Average of 2,177 mm per annum
Mean temperature: 28.45℃
GDP per capita: US$ 5,800 (2003 est.)

Palau
Capital: Koror
Population: 20,580 (2006 est.)
Land Area: 488 km^2
Max height (above sea-level): 213.5 m (Mt. Ngerechelchuus)
Rainfall: Maritime tropical rainy climate
EEZ: 629,000 km^2
Mean temperature: 27 ºC (82º F)
GDP per capita: US$ 7,600 (2005 est.)

Papua New Guinea
Capital: Port Moresby
Population: 5,670,540 (2006 est.)
Land area: 462,243 km^2
Max height (above sea-level): 4,697 m (Mt. Wilhelm)
Rainfall: Mean annual rainfall of 2000 to 6000 millimeters
EEZ: 3,120,000 km^2
Mean temperature: 26℃

GDP per capita: US$ 2,700 (2006 est.)

Samoa
Capital: Apia
Population: 176,910 (2006 est.)
Land area: 2,935 km^2
Max height (above sea-level): 1,860 m (Mt. Silisili)
Rainfall: Average annual rainfall is about 3,000 mm
EEZ: 120,000 km^2
Mean temperature: 25℃
GDP per capita: US$ 2,100 (2005 est.)

Solomon Islands
Capital: Honiara
Population: 552,440 (2006 est.)
Land area: 28,785 km^2
Max height (above sea-level): 2,447 m (Mt. Makarakombou)
EEZ: 1,340,000 km^2
Rainfall: Varies from 3,000 - 5,000 mm per annum
Mean temperature: 26℃
GDP per capita: US$ 600 (2005 est.)

Tonga
Capital: Nuku'alofa
Population: 114,690 (2006 est.)
Land area: 718 km^2
Max height above sea-level: 1, 030 m (extinct volcano, Kao)
EEZ: 700,000 km^2
Rainfall: 1,775.5 mm
Mean temperature: 24.7℃
GDP per capita: US$ 2,200 (2005 est.)

Tuvalu
Capital: Funafuti
Population: 11,810 (2006 est.)
Land area: 26 km^2
Max height (above sea-level): Approximately 5 m
Rainfall:
EEZ: 1.3 million km^2
Mean temperature: 30 ºC
GDP per capita: US$ 1,600 (2002 est.)

Vanuatu
Capital: Port Vila
Population: 208,870 (2006 est.)

Land area: 12,190 km^2
Max height (above sea-level): 1,877 m (Mt. Tabwemasana)
Rainfall:
EEZ: 710,000 km^2
Mean temperature: 24℃
GDP per capita: US$ 2,900 (2003 est.)

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