Chapter 4
Adapting to Climate Change

Climate change is likely to have substantial and widespread impacts on Pacific Island countries, affecting sectors as varied as health, coastal infrastructure, water resources, agriculture, forestry and fisheries. This chapter examines the possible impacts of changes in climate on a high and a low island of the Pacific, and discusses key adaptation and financing strategies.

The chapter begins by outlining the nature of the challenges presented by climate change (Section A). Section B describes climate change scenarios for the Pacific Island region, while Section C examines the potential impacts of these scenarios on coastal areas, water resources, agriculture, health, and fisheries. Section D summarizes the economic costs resulting from these impacts. Section E outlines a general adaptation and financing strategy to enable Pacific Islands to respond to climate change. Section F summarizes key findings and recommendations. Further analysis of the impacts of climate change scenarios and an annex describing the methodology used are included in Volume IV of this report.

A. Key Challenges

Across the Pacific, atoll dwellers speak of having to move their houses away from the ocean because of coastal erosion; of having to change cropping patterns because of saltwater intrusion; of changes in wind, rainfall, and ocean currents. While these events may simply reflect climate variability, they illustrate the types of impacts likely to be felt under climate change.

Rising Vulnerability to Weather Events

Many policymakers dismiss climate change as a problem of the future. But impacts similar to those likely to result from climate change are already being felt, as the Pacific Islands become increasingly vulnerable to extreme weather events and climate variability. Growing urbanization and squatter settlements, degradation of coastal ecosystems, and rapidly developing infrastructure on coastal areas are intensifying the islands' exposure to extreme weather events. At the same time, traditional practices promoting adaptation such as multicrop agriculture are gradually weakening. These factors are contributing to increasingly severe impacts from weather events. In the 1990s alone, the cost of extreme events in the Pacific Island region exceeded US$1 billion (table 4.1).

Compounding Impacts of Climate Change

Arriving on top of this increased vulnerability, climate change will likely exacerbate the current impacts, whether or not climate variability increases in the future—and there is some evidence that it may. In low islands, the most substantial damage would come from losses to coastal infrastructure as a result of inundation, storm surge, or shoreline erosion. But climate change could also cause more intense cyclones and droughts, the failure of subsistence crops and coastal fisheries, losses in coral reefs, and the spread of malaria and dengue fever. These impacts could be felt soon: if climate change models are correct, the average sea level could rise 11–21 centimeters and average temperatures could rise 0.5^0–0.6^0C by 2025.

Table 4.1. Estimated Costs of Extreme Weather Events in the Pacific Island Region during the 1990s (millions of US$)

Event	*Year*	*Country*	*Estimated losses*
Cyclone Ofa	1990	Samoa	140
Cyclone Val	1991	Samoa	300
Typhoon Omar	1992	Guam	300
Cyclone Nina	1993	Solomon Islands	–
Cyclone Prema	1993	Vanuatu	–
Cyclone Kina	1993	Fiji	140
Cyclone Martin	1997	Cook Island	7.5
Cyclone Hina	1997	Tonga	14.5
Drought	1997	Regional	> 175[a]
Cyclone Cora	1998	Tonga	56
Cyclone Alan	1998	French Polynesia	–
Cyclone Dani	1999	Fiji	3.5

– Not available.

a. Includes losses of US$160 million in Fiji (Stratus 2000).

Note: Minor events and disasters in Papua New Guinea not included. Costs are not adjusted for inflation.

Source: Campbell 1999.

Table 4.2. Climate Change and Variability Scenarios in the Pacific Island Region

Impact		*2025*	*2050*	*2100*	*Level of Certainty*
Sea level rise (centimeters)		11–21	23–43	50–103	Moderate
Air temperature increase (degrees Centigrade)		0.5–0.6	0.9–1.3	1.6–3.4	High
Change in rainfall (percent)	Fiji	-3.7–+3.7	-8.2–+8.2	-20.3–+20.3	Low
	Kiribati	-4.8–+3.2	-10.7–+7.1	-26.9–+17.7	Low
Cyclones					
Frequency			Models produce conflicting results		Very low
Intensity (percentage increase in wind speed)			0–20		Moderate
El Niño Southern Oscillation (ENSO)			A more El Niño –like mean state		Moderate

Note: Ranges given reflect a best-guess scenario (lower value) and a worst-case scenario (higher value). For details and sources, see volume IV, annex A.

B. Climate Change Scenarios

In 1999─2000, the World Bank helped sponsor a study of potential impacts of climate change scenarios and adaptation options in the Pacific Island region.[8] Based on the best scientific information available for the region, the following scenarios were used (table 4.2):

- ***Rise in sea level.*** Sea level may rise 0.5 meters (in a “best-guess” scenario) to 1 meter (in a “worst-case” scenario) by 2100.
- ***Increase in surface air temperature***. Air temperature could increase 1.6^0–3.4^0C by 2100.
- ***Changes in rainfall.*** Rainfall could either rise or fall—most models predict an increase—by about 20 percent in 2100, leading to more intense floods or droughts.
- ***Increased frequency of El Niño-like conditions***. The balance of evidence indicates that El Niño conditions may occur more frequently, leading to higher average rainfall in the central Pacific and northern Polynesia.
- ***Increased intensity of cyclones***. Cyclones may become more intense in the future, with wind speeds increasing by as much as 20 percent; it is unknown, however, whether cyclones will become more frequent.

[8] The study was the product of a collaboration with the International Global Change Institute, the Pacific Islands Climate Change Assistance Programme country teams in Fiji and Kiribati, the South Pacific Regional Environmental Programme, Stratus Consulting Inc., the Center for International Climate and Environmental Research, and experts from numerous other national and regional agencies, as listed in the *Acknowledgments.* Background studies are listed in *References.* Volume IV describes the detailed results and methodology.

How certain is climate change? The Intergovernmental Panel on Climate Change (IPCC) stated in 1995 that “the balance of evidence suggests a discernible human influence on global climate change” (IPCC, 1995). Uncertainties remain, however, particularly at resolutions with sufficient detail to encompass small island states.

Some changes are more certain than others. There is emerging consensus that global average temperatures and sea level will increase. Rainfall changes remain highly uncertain, however, as does the relationship between long-term climate change and extreme events. Uncertainty also increases with time: projections for 2100 are less certain than projections for 2050. Global changes are more certain than regional or island-specific changes. And impacts on coastal areas and water resources are generally more certain than impacts on agriculture and health. Although there are uncertainties on the magnitude and timing of the changes, most studies consider the Pacific Islands to be at high risk from climate change and sea level rise (Kench and Cowell 1999).

Based on the results of the study, the physical and economic impacts of climate change in the Pacific Island region are illustrated here by the example of a high island ─ Viti Levu in Fiji ─ and a group of low islands ─ the Tarawa atoll in Kiribati. To give perspective to the analysis, the economic damages were estimated for 2050 as if the impacts had occurred under today’s socio-economic conditions. Ranges provided represent a “best guess” scenario (the lower bound) and a “worst case” scenario (the upper bound). All economic costs reflect 1998 US dollars, and assume no adaptation.

C. The Likely Impacts of Climate Change

Impact on Coastal Areas

Climate change is likely to affect coastal areas in three major ways: through a rise in sea level, leading to erosion and inundation; through more intense cyclones and storm surges; and through higher sea surface temperatures, leading to a decline in coral reefs (figure 4.1).

High islands may experience similar impacts as Viti Levu, where coastal erosion may claim 2 to 4 percent of the land below 10 meters altitude by 2050, leading to average annual losses of US$2.9-$5.8 million. By 2100, the proportion of land eroded could reach 5 to 10 percent. Due to the existing level of coastal protection and the topography, the impact of inundation is expected to be relatively minor. However, in years of strong storm surge, Viti Levu could experience losses in capital assets of US$75-$90 million by mid-century. If the worst case scenarios of sea level rise materialize by 2100, downtown Suva could experience serious flooding even during moderate cyclones.

The impact of sea level rise would be most severe in the low islands of the Pacific. In Tarawa, though the impact of coastal erosion is expected to be modest (3–4 percent of the land by 2100), inundation could lead to annual average damages of US$6.6 to US$12.4 million by 2050. Periodic storm surges could result in the inundation of up to 55 to 80 percent of land areas in North Tarawa, and 25 to 54 percent of areas in South Tarawa by 2050 (figure 4.2).

The net impact of sea level rise on mangroves is unclear, and could even be beneficial in some sites if the sea level rises gradually. Coral reefs, on the other hand, could be significantly affected by climate change. Many corals may not be able to adapt to warmer sea surface temperatures and to increased concentration of carbon dioxide in the atmosphere, both of which inhibit coral growth. Bleaching events and subsequent reef mortality are expected to become more frequent, leading potentially to a decline in reef fisheries and a long-term reduction in coastal protection.

Figure 4.1. Likely Impact of Climate Change on Coastal Areas of Pacific Island Countries

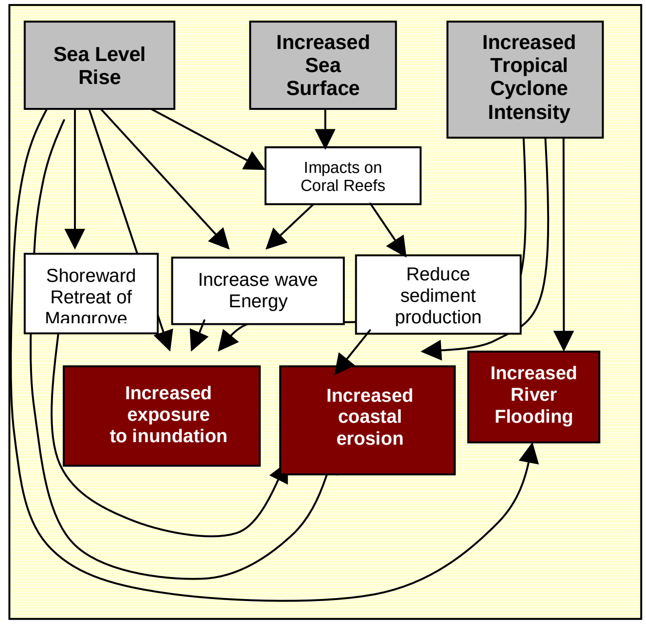
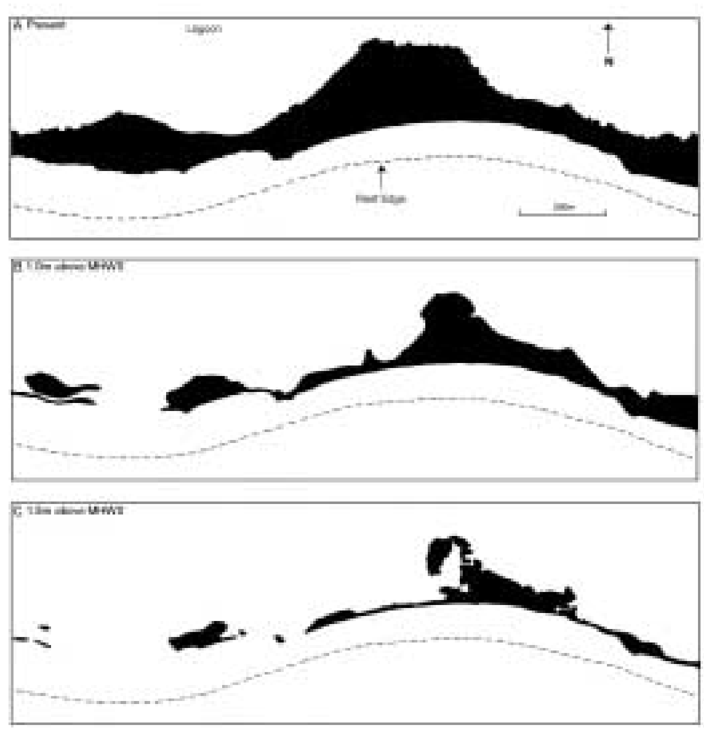


Figure 4.2: Scenarios of Inundation of Bikenibeu Island, South Tarawa (Kiribati)



A: Present status; B: Residual island under a worst case scenario, 2100;
C: Residual island under worst case scenario and storm surge, 2100
Source: Background studies to this report.

Impact on Water Resources

Climate change is likely to affect the water resources of Pacific Island countries through variations in rainfall, evapo-transpiration – caused by rising temperatures – and a rise in sea level. It is also possible that islands such as Viti Levu would experience greater climate variability, with alternating floods and droughts brought on by more intense cyclones and fluctuations in El Niño/La Niña events.

For Tarawa (and perhaps for many other low islands in the Pacific) such trends would impact the vital groundwater resources of the atoll. If climate change scenarios prove correct and rainfall changes by 7—10 percent, the sea level rises by 0.4 meters, and the islands' width is reduced through inundation, the thickness of Tarawa's main groundwater supply could decline by 19—38 percent by 2050. The resulting economic losses could average US$0.7—$2.7 million a year, and require the development of alternative groundwater sources, desalination, or rainfall collection.

In Viti Levu, rainfall variations could cause a 10 percent change in river flow by 2050 and a 20 percent change by 2100. This could lead to substantial river flood damage if scenarios of increased rainfall materialize. Provided that the distribution system was kept fully efficient, a scenario of reduced rainfall would not become a substantial threat for the water supply of western Viti Levu until the second part of the century, but could then result in demand outstripping supply by as much as 38 percent by 2100.

The combination of a warmer – and possibly drier – climate with potentially more prevalent El Niño conditions could lead to more intense droughts in Viti Levu. Droughts of the severity of the 1997/98 event—which caused losses of more than US$70 million, not counting impacts on agriculture—could become the norm in the future.

Figure 4.3. Likely Impact of Climate Change on the Water Resources of a Low Island (Tarawa, Kiribati)

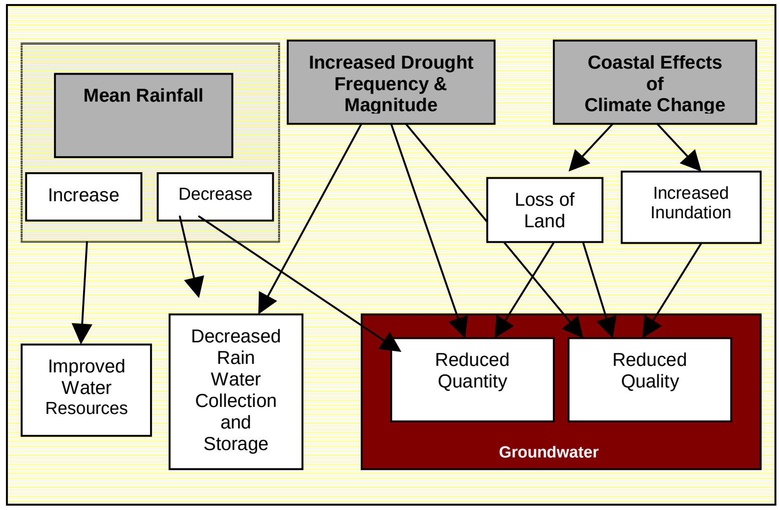


Table 4.3. Estimated Average Annual Economic Impact of Climate Change on Water Resources of Tarawa and Viti Levu, 2050 (millions of 1998 US$)

Category	*Annual damage*
Tarawa Atoll:	
Combined effect of sea level rise, changes in rainfall and reduced island width[a]	0.7—2.7
Total	**0.7—2.7**
Viti Levu:	
Changes in average rainfall	+
Increased severity and/or frequency of El Niño–related drought	+
Increased cyclone intensity	0–11.1
Total	**>0-11.1**

[a] – Assumes sea level rise of 0.4 meters, 7% increase to 10% decrease in rainfall, and reduced island width.
+ Likely to have significant economic costs but impact could not be quantified.
Note: The range given reflects a best guess and a worst case scenario.
Source: Background studies to this report.

Regional studies indicate that cyclone intensity may increase by 0—20 percent as a result of climate change (Jones and others, CSIRO 1999). A 20 percent increase in maximum wind speed could result in 44—100 percent higher damages than experienced today,[9] costing Viti Levu up to US$11 million a year by 2050 (table 4.3).

[9] Based on the costs of actual events recorded by the Fiji Meteorological Services, Clark (1997) and J. Terry (personal communication, May 2000).

Impact on Agriculture

Climate change is most likely to affect agricultural production through changes in rainfall. Agricultural crops could also be affected by rising temperatures, climate variability — such as more intense cyclones and El Niño/La Niña conditions — and sea level rise (figure 4.4).

If wetter conditions prevail in the future, water-sensitive crops such as coconut, breadfruit and cassava would likely benefit. A rainfall decline, by contrast, would hurt most crops. In a low island such as Tarawa, coconut production and *te babai* (giant taro) would be particularly affected given their sensitivity to reductions in rainfall and groundwater.

In Viti Levu, increases in rainfall during good years may offset the impacts of warmer temperatures. But a warmer — and possibly drier – climate could lead to more intense droughts during El Niño years. This could result in a 9 percent average drop in sugarcane production levels from current conditions, and in losses averaging US$13.7 million a year by 2050. In drought years, production of sugarcane could drop by half, with a shortfall of agricultural production approaching US$90 million. These periodic droughts could well prove to be the most disruptive to the Fijian economy once preferential trade agreements are phased out.

The impacts of climate change on traditional crops, such as yam and taro, could also affect the subsistence economy of the Pacific Islands. In Viti Levu, a declining rainfall scenario and future El Niño/La Niña conditions could lead to a 11—15 percent shortfall in taro, yam, and cassava yields (figure 4.5). Even in scenarios of increasing rainfall, future climate variability could cost Viti Levu an average of US$68,0000 a year in lost food crops (though crops such as yam would likely benefit).

In the low islands of Tarawa, sea level rise would affect agriculture crops through saltwater intrusion – affecting *te babai* (giant taro) production in particular — and through loss of coastal land to inundation, which may reduce production of copra, breadfruit and pandanus.

Figure 4.4. Likely Impacts of Climate Change on Agriculture in Viti Levu, Fiji

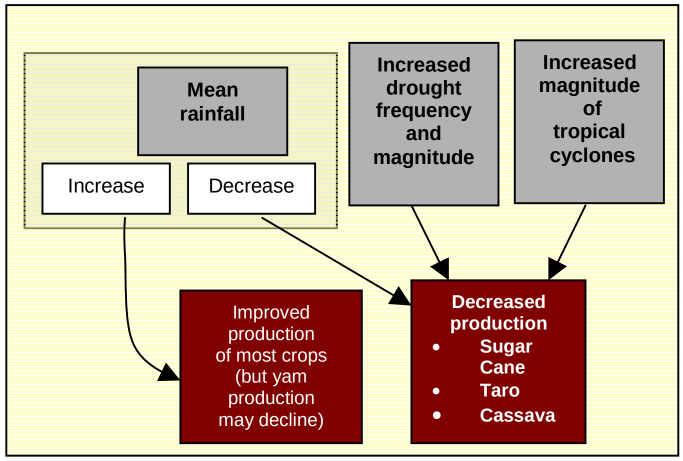
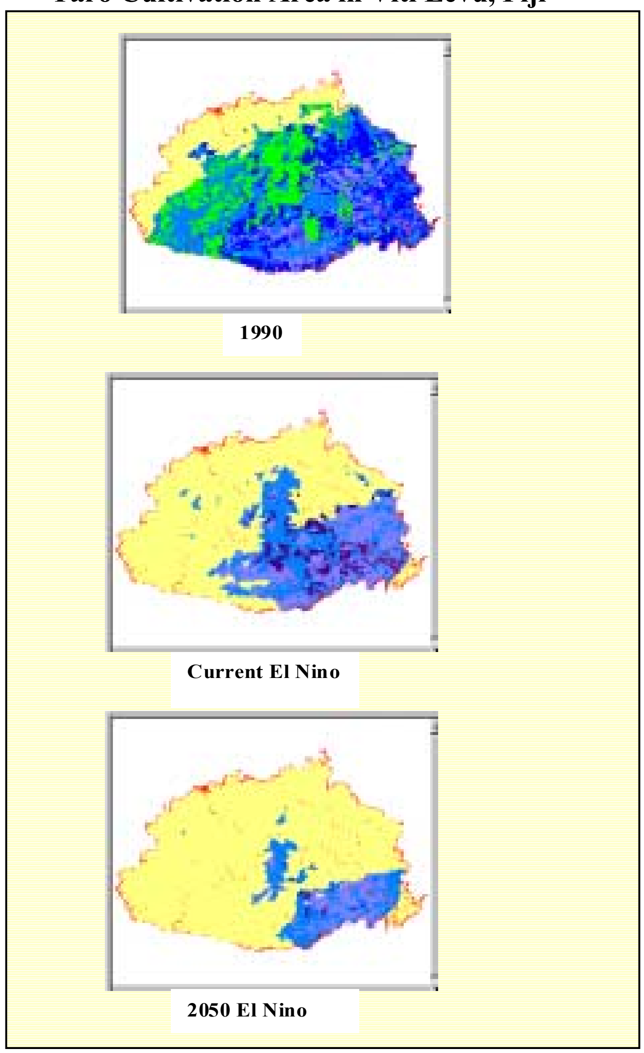


Figure 4.5. Effect of El Nino—induced Droughts on Taro Cultivation Area in Viti Levu, Fiji



Note: Shaded areas show land suitable for cultivation.
Source: Background studies to this report.

Impact on Health

Climate change could have significant impacts on public health due to the higher temperatures (0.9—1.3° C by 2050), changes in water supply and extreme events, and a decline in agriculture production. Likely impacts would include:

- *Direct impacts on public safety,* such as injuries, illness, and loss of lives due to cyclones or droughts.
- *Indirect effects,* such as increased incidence of vector-borne diseases (dengue fever and malaria), waterborne diseases (diarrhea), and toxic algae (ciguatera).
- *Nutrition-related diseases,* particularly malnutrition and food shortages during extreme events.

These impacts are likely to be particularly severe for the poor. Poor households – particularly in towns – will be more vulnerable to the impacts of climate change because of their greater propensity for infectious diseases, limited access to medical services, substandard housing, and exposure to poor environmental conditions. Many of the urban poor may also lack access to the safety nets that assisted them traditionally in times of disaster.

Climate change could cause significant increases in the frequency, severity, and distribution of dengue fever. The higher temperatures would increase the biting rate of mosquitoes and decrease the incubation period of the dengue virus. In Viti Levu, the number of cases could increase by 20─30 percent in 2050, and as much as 100 percent by 2100 (under a worst case scenario). In countries where the malaria vector is found, the distribution and prevalence of the disease is also likely to expand (WHO 1996).

Diarrhea disease is likely to become more common in a warmer world, particularly under a scenario of decreasing rainfall. Sea level rise could also increase the incidence of diarrhea by disrupting sanitation and water supplies.

Climate change could increase the incidence of ciguatera poisoning in some areas. Kiribati already has one of the highest rates of ciguatera poisoning in the Pacific (Lewis and Ruff, 1993). The rise in temperatures is expected to increase the incidence of ciguatera poisoning from 35─70 per thousand people to about 160─430 per thousand in 2050 (table 4.4).

More intense cyclones and droughts are likely to increase nutrition-related deficiencies, as experienced in Fiji during the 1997/98 drought, when US$18 million in food and water rations had to be distributed (UNDAC 1998). Loss of agriculture and fisheries could result in malnutrition and deterioration in standards of living. And the loss of land and infrastructure could lead to increased crowding conditions, exacerbating problems of urban management. These diffuse effects could well prove to be among the most important impacts of climate change on public health in the future.

Table 4.4. Estimated Increases in Dengue Fever Epidemic Potential and Incidence of Ciguatera Poisoning in Kiribati as a Result of Climate Change, 2025–2100

Impact	*Baseline 1990*	*2025*	*2050*	*2100*
Dengue fever				
Projected epidemic potential[a]	0.18	0.20	0.22─0.24	0.25─0.36
Percentage change from 1990	—	11	22–33	39–100
Ciguatera poisoning incidence (per thousand population)	35─70	105─240	160─430	245─1,010

[a] - The epidemic potential index measures the efficiency of disease transmission. A value of 0.2 or above indicates a high epidemic potential.

Note: Ranges indicate best-guess and worst-case scenarios. For assumptions, see volume IV, annex A of this report.

Source: Background studies to this report.

Impact on Regional Tuna Fisheries

Climate change is likely to affect tuna fisheries of the Central and Western Pacific in two major ways: by raising average ocean temperatures to levels currently experienced during medium-intensity El Niños and by increasing year-to-year climate variability (Timmermann and others, 1999). The impacts are likely to be pervasive, affecting the distribution, abundance, and catchability of tuna fisheries:

- *Decline in primary productivity.* Primary productivity in the central and eastern Pacific could decline due to the increased stratification between warmer surface waters and colder, deeper water (and resulting reduction in upwelling). Primary productivity in the western Pacific could conversely increase.

- *Decline in tuna abundance.* The decrease in upwelling would lead to a decline in the bigeye and adult yellowfin population (the species targeted by the longline fleet). By contrast, the abundance of purse-seine-caught skipjack and juvenile yellowfin tuna is not expected to be affected.

- *Increased pressure on longline fishing.* Given the continued high demand for sashimi in Japan, it is likely that longline fishing pressure on yellowfin tuna will increase to compensate for the decline in adult bigeye tuna, leading to unsustainable exploitation.

- *Spatial redistribution of tuna resources.* The warming of surface waters and the decline in primary productivity in the central and eastern Pacific could result in spatial redistribution of tuna resources to higher latitudes (such as Japan) and towards the western equatorial Pacific.

- *Increase in climate variability.* With the likely rise in climate variability (Jones, 1999), there may be an increase in the annual fluctuations of the spatial distribution and abundance of tuna. It is possible that more frequent cold events (such as strong La Niña episodes) may compensate for the decrease in productivity under an El Niño mean state. However, a strong future El Niño – which has no parallel in the present climate – could lead to a dramatic decline in productivity in the eastern Pacific (see box 4.1).

Box 4.1. Likely Future Climate

Likely future climate	***Correspondence with present climate***
Mean state	Moderate El Niño
Moderate El Niño event	Strong El Niño event
Strong El Niño event	Unknown, extremely warm event
Moderate La Niña	Current mean state
Strong La Niña	Moderate La Niña

- *Higher impact on domestic fleets.* While distant water fishing fleets can adapt to stock fluctuations, domestic fleets would be vulnerable to fluctuations of tuna fisheries in their exclusive economic zones. Countries in the central Pacific, such as Kiribati, would likely be more adversely affected than those in the western Pacific.

D. Economic Costs of Climate Change

The aggregate economic costs of climate change impacts could be substantial. Estimates from this study indicate that if climate change scenarios materialize, the island of Viti Levu in Fiji could suffer economic damages averaging at least US$23–$52 million a year by 2050 (in 1998 dollar value), equivalent to 2–4 percent of Fiji's gross domestic product. Because these losses are annual averages, they dampen the actual costs of extreme weather events, which could be considerably higher in a given year. A cyclone might cause damages of about US$40 million, while a severe drought could cost Viti Levu some US$70 million in lost crops.

The Tarawa atoll in Kiribati could face average annual economic damages of US$8 million to over US$16 million by 2050 (as compared with a GDP of about US$47 million). In years of strong storm surge, up to 54 percent of South Tarawa could be inundated, with capital losses of up to US$430 million (table 4.5).

Table 4.5. Estimated Annual Economic Impact of Climate Change, 2050 (millions of 1998 US$)

Impact	*Average Annual damage*[a]		*Likely Cost of an Extreme Event*[b]		*Extreme Event*
	Viti Levu	*Tarawa*	*Viti Levu*	*Tarawa*	
Impact on coastal areas					
Loss of coastal land and infrastructure to erosion	3—6	0.1—0.3	–	–	–
Loss of coastal land and infrastructure to inundation and storm surge	0.3—0.5	7—12	75-90	210—430	Storm Surge
Loss of coral reefs and related services	5—14	0.2—0.5	–	–	–
Loss of nonmonetized services from coral reefs, Mangroves and seagrasses	+	+	–	–	–
Impact on water resources					
Increase in cyclone severity	0–11	–	40	–	Cyclone
Increase in ENSO–related droughts	+	+	70-90	–	Drought
Replacement of potable water supply due to change in precipitation, sea level rise, and inundation	+	1–3	–	–	–
Changes in annual rainfall (other than impacts on agriculture)	+	+	–	–	–
Impact on agriculture					
Loss of sugarcane, yams, taro, and cassava due to temperature or rainfall changes and ENSO effects	14	+	70	_	Drought
Loss of other crops	+	+	–	–	–
Impact on public health					
Increased incidence of dengue fever	1-6	+	40	–	Large epidemic
Increase in fatal dengue fever cases	+	+	–	–	–
Increased incidence of diarrhea	0 –1	+	–	–	–
Infant mortality due to diarrhea	+	+	–	–	–
Impact of cyclones and droughts on public safety	+	+	–	–	–
Total estimated damages	**>23—52+**	**8–16+**			

\+ Likely to have economic costs but impact not quantified. -- Not available

[a] Reflects incremental average annual costs due to climate change. [b] Reflects the actual cost of an extreme event.

Note: For assumptions, see Volume IV of this report, Annex A. Ranges indicate a best guess (lower bound) and a worst case scenario (higher bound).

Source: Background studies to this report.

E. Toward Adaptation: Moderating the Impacts of Climate Change

The estimated economic costs of climate change assume no adaptation. In practice, Pacific Island governments and communities could help offset these costs by undertaking adaptation measures.[10] The question is determining which adaptation measures are best in the face of uncertain future impacts.

There is little Pacific Islands can do to prevent climate change. At the same time, Pacific Island governments cannot afford to ignore the problem. Adapting to climate change may soon become an economic and political imperative.

The Need for Immediate Action

The development choices made by Pacific Island governments today will have a profound impact on the future vulnerability of the islands and on the magnitude of climate change impacts.

One of the most compelling arguments for acting now is the growing impact of extreme weather events in the Pacific. Even those who

[10] *Adaptation* refers here to any measures that protects the Pacific Island countries against the impacts of climate change. *Mitigation*, by contrast, refers to the reduction of greenhouse gas emissions.

argue that climate change may never happen cannot dispute the urgency of reducing the islands' vulnerability against severe climate events. The recent drought and the sequence of cyclones which affected many Pacific Islands during the 1990s attest to an increasing exposure that will, sooner or later, put mounting public pressure on governments and politicians to act. No less compelling is the fact that under an increasing globalized economy, those countries which invest early on adaptation—and, in the process improve the quality of life and reduce investment risks—are likely to hold a competitive advantage for foreign investment (see Chapter 1). As measures to reduce vulnerability are also among the most effective in adapting to climate change, acting now to reduce current vulnerability will also prepare the Pacific Islands for the long-term effects of climate change.

Another reason for acting now is that failure to do so may result in a loss of opportunities that may not exist in the future. Coral reefs, for example, may not be able to recover from bleaching events if they are weakened by pollution and mining.

Finally, adaptation strategies may require several decades to be discussed and implemented. Communities living in low-lying areas, for example, may need to relocate further inland to other communities' customary land. This will require extensive public debates on how to place the common good of all above the good of the clan or immediate family, a process that cannot—and should not—be rushed.

Since it is difficult to predict far in advance how climate change will affect a particular site, Pacific Island countries should avoid adaptation measures that could fail or have unanticipated social or economic consequences if climate change impacts turn out to be different than anticipated (IPCC 1998). More appropriate will be 'no regrets' adaptation measures that would be justified even in the absence of climate change. These include, for example, sound management of coastal areas and water supplies, control of pollution, and investment in preventive health.

As it will be shown, a 'no-regrets' adaptation strategy need not involve large investments of public resources — but it will require strong political will, as adaptation measures may face strong competition from other development activities for scarce funds. Yet it is important to understand that the short-term economic gains of a 'do nothing' strategy could be easily dissipated by the impact of future climate events.

A development path that takes adaptation into account might sacrifice some potential short-term gains in favor of more diversification and a reduction in vulnerability. But it would vastly decrease the downside costs should climate change scenarios materialize. The challenge will be to find an acceptable level of risk — an intermediate solution between investing in high cost solutions and doing nothing — and start adapting long before the expected impacts occur.

Guidelines for Selecting Adaptation Measures

Pacific Island countries have a vast array of adaptation measures at their disposal. The following criteria could help guide their selection:

1. *No regrets.* Give priority to 'no regrets' measures, such as water resources management, which would be beneficial even in the absence of climate change. Structural measures such as sea walls and groynes—which provide few benefits other than protection—require a high degree of certainty about the impact at a particular site. If climate change impacts turn out to be different than expected, investments in these measures could have been wasted.

2. *Level of implementation.* Adopt general rather than site-specific measures, at least until there is more certainty about localized impacts.

3. *Bottom up or top-down.* Use community-based (bottom-up) rather than top-down interventions. Many traditional adaptation measures have been tested and adjusted over the years in response to extreme events. These

measures are likely to be more effective than top-down solutions. At the same time, communities will need external help to handle threats — such as pollution — that are beyond their control. A collaborative partnership between the government and communities may well prove to be the most effective (see chapter 3).

4. *Environmental impacts.* Select adaptation measures based on their impact on the overall vulnerability of the islands, not only on their impact at a particular site (de Wet 1999). A sea wall, for example, may solve the problems of a particular site but increase erosion downstream (figure 4.6).

5. *Cultural acceptability.* Ensure that measures are compatible with the socio-cultural traditions of local communities and do not cause social disruption.

6. *Timing.* Time measures appropriately. Some adaptation measures—such as expansion of rainwater collectors in Tarawa—may need to be implemented immediately. Others could wait while appropriate responses are developed. As a general rule, the most urgent measures are those needed to protect against current climate events and those on which it may no longer be possible to act in the future.

7. *Cost-benefit.* Chose measures where the potential benefits of adaptation clearly exceed its costs.

Table 4.6 shows a range of adaptation measures classified according to these criteria.

Two key principles should be kept in mind when selecting adaptation options. First, adaptation is not necessarily limited to interventions that reduce climate change impacts. Measures that increase the resilience of natural systems—by controlling pollution's effects on coral reefs, for example—should also be considered, as should policies that facilitate action on adaptation, such as a legislation empowering communities to manage their own reef fisheries.

Figure 4.6. A Seawall in Qoma, Fiji

Sea walls are built throughout the Pacific to protect settlements against coastal erosion and storms. However, sea walls do not solve the underlying cause of erosion and may cause further problems downstream. In Qoma, Fiji (photo above) the community reported experiencing frequent inundation, which might have been exacerbated by their sea wall. Strategic replanting of mangroves might well have been a more efficient solution to guard against periodic inundation.

Second, it is vital to consider the sociocultural conditions of the Pacific Islands. To an external observer, it may seem appropriate to reinforce traditional Samoan houses to protect against cyclones. From the local communities' point of view, however, a 'do nothing' strategy may well be justified, because labor and materials could be readily available from within the extended family and the houses might easily be rebuilt following cyclones. The adaptation process thus needs to be highly participatory and allow for adjustments as new knowledge about climate change impacts is obtained.

Implementing Adaptation

The previous sections argued for Pacific Island governments to promote 'no regrets' adaptation. But how should this strategy be implemented in practice?

Governments cannot do it alone. Adaptation measures are and will continue to be implemented primarily by communities, the private sector, and individuals. But the role of Pacific Island governments will be essential in mainstreaming adaptation into policy and

Table 4.6. Selected Examples of Adaptation Measures

Goal	*Adaptation measure*	*No regrets?*	*Level of implementation*	*Bottom up or top down*	*Negative Environmental impacts?*	*Culturally acceptable?*	*Timing*	*Cost-benefit*
Moderate impacts on coastal areas								
Protection of critical ecosystems	Increase Public awareness		Generic	Both	No	Yes	Immediate	Positive
	Prohibit extraction of reef and sand	Yes	Sector specific	Both	No	May increase building costs	Immediate	Positive
	Prevent mangrove removal	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
	Control pollution	Yes	Generic	Top down	No	Unknown	Immediate	Unknown
	Control overfishing	Yes	Sector specific	Both	No	Loss of food	Immediate	Positive
Protection of towns and property	Engineered structures (such as seawalls)	No	Site specific	Top down	Probably	Unknown	Unknown	Unknown
	Set back development from shoreline	No	Site specific	Both	Unknown	Land tenure?	Can wait	Unknown
	Raise structures	No	Site specific	Both	Unknown	Unknown	Can wait	Unknown
Land use policies	Coastal hazard mapping	Yes	Site specific	Top down	No	Yes	Immediate	Unknown
Control of erosion	Mangrove replantation	Yes	Sector specific?	Both	No	Yes	Immediate	Positive
	Engineering works in passages	No	Site specific	Top down	Probably	Unknown	Can wait	Unknown
	Groynes	No	Site specific	Top down	Probably	Unknown	Immediate	Positive(?)
Moderate impacts on water resources								
Water resource management	Leakage control	Yes	Sector specific	Both	No	Yes	Immediate	Positive
	Pricing policies (fees, levies, surcharges)	Yes (?)	Sector specific	Top down	No	Problematic	Immediate	Positive
	Conservation plumbing	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
	Stricter penalties to prevent waste	Yes (?)	Generic	Top down	No	Resistance?	Immediate	Positive
Catchment management	Reforestation, soil conservation	Yes	Generic and site specific	Both	No	Yes	Immediate	Positive
	Establishment of a Water Authority	Yes	Sector specific	Top down	No	Unknown	Immediate	Positive
Alternative water supply	Expansion of rainwater collection	Yes	Sector and site specific	Both	Unknown	Maybe	Immediate	Unknown
	Alternative groundwater use	Yes	Sector and site specific	Top down	Unknown	Land tenure?	Can wait	Unknown
	Desalination	No (?)	Sector and site specific	Top down	Unknown	High costs	Can wait	Unknown
	Importation	No (?)	Sector specific	Top down	No	High costs	Can wait	Negative
Flood control	Diversion channels, weirs, etc.	No	Site specific	Top down	Probably	Unknown	Immediate	Unknown
	Land use controls, flood proof housing	No (?)	Site specific	Both	No	Land tenure?	Immediate	Unknown
Moderate impacts on agriculture								
Community sustainability programs	Traditional weather-resistant practices	Yes	Sector specific	Bottom up	No	Yes	Immediate	Positive
Sustainable production systems	Agroforestry, water conservation	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
Research	Flexible farming systems	Yes	Sector specific	Top down	No	Unknown	Immediate	Positive(?)
Land use policies	Mapping of suitable cropping areas	Yes	Generic	Top down	No	Unknown	Immediate	Positive
	Avoid cultivation on marginal lands	Yes	Site specific	Top down	No	Disruptive	?	Positive
Moderate impacts on public health								
Integrated adaptation strategies and control of diarrheal disease	Poverty reduction programs	Yes	Generic and site specific	Top down	Unknown	Yes	Immediate	Positive?
	Improved sanitation and water supply	Yes	Sector and site specific	Both	No	Yes	Immediate	Positive
	Waste management	Yes	Sector and site specific	Both	No	Unknown	Immediate	Positive
	Protection of groundwater	Yes	Sector and site specific	Both	No	Unknown	Immediate	Positive
	Squatter settlement management	Yes	Site specific	Both	Unknown	Yes ?	Immediate	Positive
Control of dengue fever	Community-based vector control	Yes	Sector and site specific	Bottom up	No	Unknown	Immediate	Positive
	Improved preparedness (monitoring)	Yes	Sector specific	Top down	No	Yes	Immediate	Positive
	Prevention of exposure	Yes	Sector specific	Bottom up	Unknown	Difficult?	Unknown	Unknown
Control of ciguatera poisoning	Reduce destructive practices to coral reefs	Yes	Sector specific	Both	No	Food, income?	Immediate	Positive
	Monitoring and public awareness	Yes	Sector specific	Both	No	Yes	Immediate	Positive
Moderate impacts on tuna fisheries								
Stronger regional collaboration	Multilateral agreements	Yes	Sector specific	Top down	Unknown	Distrust?	Immediate	Positive
Research	Better ENSO forecasting	Yes	Generic	Top down	No	Yes	Immediate	Positive
	Improved tuna management	Yes	Sector specific	Top down	No	Yes	Immediate	Positive
Fleet management	Diversification of domestic fleets	No	Sector and site specific	Top down	Unknown	Problematic	Can wait	Positive

development planning, in creating partnerships with communities and the private sector, and in dealing with problems only the government can handle (such as disaster management).

Mainstreaming Adaptation

Adaptation goals need to be identified as a clear priority in national policies and development plans. The objective would be to transform climate change from "something that may happen in the future" to a priority feature of current development planning.

In the short to medium term, all major new development projects—such as coastal mining and dredging—should undergo adaptation screening. This process should assess both the likely impact of climate change on the project, as well as the project's impact on the islands' vulnerability and its contribution to adaptation (de Wet 1999). Adaptation screening would not require extensive new legislation but rather a revision of environmental impact assessments to take adaptation into account. The Coastal Hazard Mapping program in Samoa is a step in this direction.

Building Partnerships

In building partnerships with communities, individuals, and the private sector, the government will need to play a pivotal role in the following areas:

- *Creating an enabling policy and legal framework.* This may include prioritizing adaptation in national planning, harmonizing conflicting sectoral policies, and providing the necessary legal and technical support for community based adaptation measures such as co-management of coastal areas.

- *Strengthening institutions.* Links between local communities and the government should be strengthened so that communities increasingly gain a voice in planning and budgetary decisions. Local communities should also be encouraged to work across village boundaries to reach consensus on the adaptive strategies that need to be applied to larger areas—particularly if relocation is likely to be needed.

- *Supporting collaborative programs.* Community-based programs, such as vector control, water conservation, coastal management, or mangrove replantation, will need the support of government and nongovernmental organizations. At first, external support should focus on galvanizing community action. Later, it should shift to technical advice and assistance in areas communities cannot handle on their own.

- *Mobilizing public action.* Public awareness and discussion forums involving community representatives could help convey information about the impacts of climate change and gain consensus on the adaptation options.

- *Handling disaster mitigation and providing public services.* Some adaptation measures will need to rely on government interventions. These include early warning systems and disaster mitigation programs, improvements in primary health care, and coastal protection in town areas.

Funding Adaptation

Much of the costs and success of adaptation will depend on the extent to which communities, individuals, and private sector own and implement the strategies. This requires government support for community-based efforts, and may require working through traditional decision making processes to ensure "buy-in" at the local level. By asking new development projects to follow adaptation standards, Pacific Island governments could also shift part of the costs of adaptation to private investors.

'No regrets' adaptation measures do not involve significant costs if started sufficiently early. Samoa's environmental health program, for example, operates with a budget of US$113,000 a year. The Coastal Zone Management Project in Majuro, financed by UNDP, cost US$367,000 for four years of operation. By contrast, sea walls surrounding the Tarawa atoll would require capital investments of about US$1.5—$1.8 million (table 4.7).

In this context, it is recommended that Pacific Island countries adopt urgently a 'no regrets' policy aimed at decreasing their present vulnerability to extreme weather events (which may exist independently of climate change). As a first step, Pacific Island governments should assess how public expenditures could be adjusted to support this strategy, and how other partners in the process—in particular communities and the private sector—may help defray the costs. As a second step, Pacific Island governments and donors should study how to reallocate or attract new development aid to fund 'no regrets' activities that cannot be adequately funded by public expenditures. Many of these interventions—such as improved sanitation or coastal management—could be justified as part of regular environmental assistance.

Table 4.7. Indicative Adaptation Costs (US$)

Measure	*Cost*
Annual Operational Costs[a]*:*	
Land use planning	33,700
Waste management	181,900
Biodiversity protection and natural parks	167,000
Environmental education and information	102,000
National disaster council	30,700
Reforestation	297,800
Watershed projection and management	113,800
Support to community-based fisheries management	81,400
Community disease control	205,800
Environmental health	112,600
Nutrition	83,400
Investment Costs:	
Human waste management (composting toilets)[b]	800,000
Elevating houses [b]	1,700,000-3,200,000
Seawalls [c]	1,540,000-1,830,000
Coastal Zone Management Project for Majuro Atoll[d]	367,300

[a] Costs reflect Samoa public expenditures for 1999-00. GDP Samoa US$205 million.
[b] Covering North Tarawa (population 6,000, area 1,500 ha). GDP Kiribati US$47.9 million.
[c] Covering Tarawa atoll (population 35,000, area 3,200 ha). The cost per linear meter is about US$155, excluding maintenance costs.
[d] Costs represent allocation for four years for Majuro (population 86,110).
Source: Legislative Assembly of Samoa 1999; UNDP 1996; background studies to this report.

Even though 'no regrets' measures have the double benefit of reducing short-term exposure to climate variability as well as long-term vulnerability to climate change, it is important that the two aspects be kept separate in international negotiations. Adoption of an early 'no regrets' strategy by a country should not diminish its chances of accessing climate change adaptation funds in the future.

Similarly, donors should not be led to believe that because 'no regrets' adaptation benefits the countries independently of climate change, the justification for incremental financing is weak. To do so would be to tip the scale in favor of structural solutions (such as seawalls), which are clearly incremental. Government officials in the Pacific Islands have often expressed the view that it is easier to obtain international aid for structural measures than for 'no regrets' solutions. These disincentives need to be addressed in future international climate change discussions, in order to maintain 'no regrets' strategies at the forefront of adaptation financing, and benefit, rather than penalize the countries most willing to take early action.

Globally, the United Nations Framework Convention on Climate Change (UNFCCC) provides the umbrella agreement for mitigation of greenhouse gas emissions. The Convention also includes provisions to begin work on adaptation to climate change. To date, however, progress on adaptation has been slow. The perception among many observers is that the high costs of adaptation have overruled enthusiasm to assist those countries most in need of support. As a consequence, funds from the Global Environmental Facility (GEF), the main financing mechanism for climate change, have been available only for mitigation of greenhouse gas emissions and for studies and capacity building. International negotiations under the Conference of Parties of the UNFCCC have not yet agreed to the financing of actual adaptation (Stage III) measures.

Pacific Island countries are understandably concerned about the slow pace of these negotiations. They view the stalling of Phase III as a way for emission-producing countries to avoid recognizing their responsibilities toward countries on the receiving end of climate change.

The findings of this report clearly show that the Pacific Islands are likely to experience significant incremental costs associated with global climate change in the future. The responsibility is now on the international community to move urgently with a financing mechanism to help the coastal states defray these costs. The urgency of this action for small states such as the Pacific Islands cannot be over-emphasized.

At the same time, Pacific Island countries should continue to speak with one voice at international climate change forums. Much has been done already under the support of the Pacific Islands Climate Change Programme (PICCAP). A strengthened focus on optimal adaptation strategies, and economic analysis─particularly on costs and benefits of adaptation measures─could strengthen their case in international negotiations, broaden the climate change constituency, and mainstream climate change into the economic and development planning of the Pacific Islands.

F. Summary of Key Findings and Recommendations

The following conclusions can be derived from the analysis:

- ❑ The Pacific Islands are already experiencing severe impacts from climate events. This is evidenced by cyclone damage of more than US$1 billion during the 1990s and by the impact of recent droughts in Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, and Palau (SPREP 2000).
- ❑ The islands' vulnerability to climate events is growing, independently of climate change. Current trends point to a continuing rise in vulnerability in the future which will be exacerbated by climate change.
- ❑ Climate change is likely to impose major incremental social and economic costs on Pacific Island countries. In disaster years the impact could be particularly high, causing significant economic and social problems.
- ❑ Climate change may affect all Pacific Islanders, particularly the poor and most vulnerable. Climate change may also exacerbate poverty by reducing coastal settlement areas and affecting the crops and fisheries on which many communities depend.
- ❑ Failure to adapt now could not only lead to major damages, but also result in a loss of opportunities to act in the future. Some coral reef areas, for example, may no longer be able to recover in the future if degradation continues at the present rates.
- ❑ By acting now to reduce their present-day vulnerability to extreme weather events, Pacific Island countries could go a long way toward diminishing the effects of climate change in the future.

Based on these conclusions, a number of key recommendations can be derived.

Pacific Island Governments

- *Adopt a 'No Regrets' Adaptation Policy.* Pacific Island governments should put in place an urgent policy of 'no regrets' adaptation, aimed at increasing the natural resilience of the islands and reducing their vulnerability to present-day weather events. 'No regrets' measures could include, for example, the management of critical coastal ecosystems (such as coral reefs), control of urban pollution, water conservation, culture of weather-resistant crops, and disease vector control. Under such a policy, Pacific Island governments would take adaptation goals into account in future expenditure and development planning. Insofar as these measures helped reduce existing vulnerability (independently of climate change), Pacific Island governments would be justified in using reallocations of public expenditures and development aid to fund these activities.

- *Develop a Broad Consultative Process for Implementation of Adaptation.* Pacific Island governments should start a process of consultation with community representatives, the private sector, and other civil society institutions (such as churches and NGOs), on a national strategy for adaptation. The strategies should build upon the National Communications developed by the PICCAP country teams. The objective would be mainstream adaptation into national policies and development plans, to gain consensus on priority adaptation measures, and to build partnerships for their implementation.

- *Require Adaptation Screening for Major Development Projects.* To help defray future costs, Pacific Island governments should require all major infrastructure projects to undergo adaptation screening as part of an expanded environmental impact assessment.

- *Strengthen Socio-Economic Analysis of Adaptation Options.* Further work on the specific socio-economic impacts of climate change and adaptation—such as done under this report—could help strengthen the Pacific Island countries' position in international discussions on adaptation financing. A better understanding of the physical and economic impacts would also help mainstream climate change into broader development planning.

Donors

- *Support 'No Regrets' Adaptation.* Donors have an important role to play in discussing with Pacific Island countries how to best orient development assistance in support of national adaptation strategies. This could be done either through stand alone interventions or as part of natural resources and environmental management programs.

- *Support Adaptation Screening.* To the extent possible, donors should adopt adaptation screening as part of their policy requirements on environmental impact assessments.

International Community

- *Operationalize Adaptation Financing.* Given the importance of taking early action on adaptation, the international community needs to urgently agree on the mechanism and size of adaptation financing—be it in the form of the Global Environmental Facility, a tax on the Clean Development Mechanism as currently discussed, or others. The findings from this study support the argument that Pacific Island countries will likely experience significant incremental costs from climate change, and will need access to global adaptation funding.

- *Remove Incentives against Immediate Action on 'No Regrets' Adaptation.* Countries that have taken early action on adaptation using their own public expenditures or development aid should not be penalized with a lower allocation of global adaptation funds, once these become available. Similarly, the incrementality of 'no regrets' adaptation needs to be recognized and promoted in its own right. Failure to do so could tilt the balance towards a 'wait and see' attitude, in favor of more expensive, but clearly incremental, structural solutions (such as seawalls).

Although many uncertainties remain, it now seems clear that climate change will affect many facets of Pacific Island people's lives and economies in ways that are just now beginning to be understood. Climate change therefore must be considered one of the most important challenges of the twenty-first century and a priority for immediate action.