ADB

Pacific Studies Series

Food Security and Climate Change in the Pacific

RETHINKING THE OPTIONS

Asian Development Bank

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Abbreviations

ADB	—	Asian Development Bank
APEC	—	Asia–Pacific Economic Cooperation
cm	—	centimeter
DMC	—	developing member country
ENSO	—	El Niño Southern Oscillation
FAO	—	Food and Agriculture Organization of the United Nations
FICI	—	Food Import Capability Index
FSM	—	Federated States of Micronesia
GDP	—	gross domestic product
GEF	—	Global Environment Facility
IPCC	—	Intergovernmental Panel on Climate Change
km^2	—	square kilometer
NAPA	—	national adaptation program of action
PNG	—	Papua New Guinea
UNFCCC	—	United Nations Framework Convention on Climate Change

Foreword

The Asian Development Bank (ADB) has been promoting development in its Pacific developing member countries through technical assistance, grants, and loans for 4 decades. In view of mounting concerns in the Pacific on the potential effects of climate change on economic development, the Pacific Department created a Pacific Climate Change Program to focus on the impact of climate change in key sectors of island economies, including agriculture and natural resources management, which provide the basis of food security. In recent years, the issue of food security has become more and more prominent internationally and in the Pacific region. The Pacific countries held the Pacific Food Summit in April 2010 and produced *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific*.

This report examines the issues of food security and climate change in the Pacific in depth, looks beyond the present directions of island development, and, based on the Pacific food security framework, suggests focal areas of assistance for ADB and other development partners for improving food security, including some that are different from those currently being pursued but could lead to better food security in Pacific countries.

The report was prepared by the Pacific Department under the supervision of Robert Guild, director of Transport, Energy, and Natural Resources Division. Mahfuzuddin Ahmed, principal natural resources Specialist, led the preparation and publication. Consultants Roberta Gerpacio, Jay Maclean, and Mercedita Sombilla also assisted in preparing the draft of the paper. Teri Temple edited, while Aldwin Sutarez proofread the publication. Ophie Iriberri provided editorial assistance, Cecilia Caparas coordinated the publishing process and Linel Ann Reyes provided overall administrative assistance.

Robert Wihtol
Director General
Pacific Department

Executive Summary

The Pacific developing member countries (DMCs) of the Asian Development Bank (ADB) are a diverse array of countries with widely varying topographies, cultures, and economies, but generally characterized by their small physical size and geographical remoteness, fragile biodiversity, and a limited natural resource base. Most, if not all, Pacific countries are also confronted with extraordinary circumstances with respect to climate change. The prosperity, stability, and security of Pacific countries can be compromised by the impacts of climate change on food production; use of land, coastal, and marine resources; damage to infrastructure and water resources; and risks to human health, thereby creating significant development challenges for the region. The Pacific island governments view climate change as a priority issue, especially in terms of its potential impacts on food security, but need clear directions in addressing both issues.

The Pacific Food Summit held in Port Vila, Vanuatu on 21–23 April 2010 was the first time Pacific leaders in health, agriculture, and trade have come together with industry to take action on food security. The Summit reviewed threats to food security, discussed best practices for improving it, and endorsed a Framework for Action on Food Security to guide multi-sectoral and coordinated response in improving food security within the Pacific countries and across the region. The Framework recognized the importance of traditional agriculture, community involvement, climate resilience, and emergency systems and safety nets in ensuring food security in the face of climate change.

This report describes the present state of food security and its contributing factors in the Pacific region, assesses its prospects amid the growing threats and likely impacts of climate change, and describes potential areas for more active assistance, investments and interventions from ADB and other development partners.

Context

The Pacific countries are grouped into those composed mainly of large, high, and fertile volcanic islands and those of low atolls with relatively infertile soils. The larger, higher islands have more agricultural potential and "highland" populations living far from coastal fisheries, while the low-lying countries generally have limited agricultural potential and cultures that are more attuned to the sea. Annual growth of the total agriculture sector in the Pacific region generally slowed (but remained positive) between the 1990s and 2000s, same with the sector's contribution to gross domestic product (GDP). The region's vast coastal and marine resources—with some countries having 100–1,000 times bigger exclusive economic zones—historically played a significant role in shaping local cultures, especially food, income, and livelihood systems.

The current population of 10.1 million of ADB's Pacific DMCs has been increasing at an average annual rate of 1.9%, with the highest growth rates in Melanesia and the lowest in Polynesia. Increasing rural-to-urban migration and rapid urbanization in the region are significantly contributing to these sociodemographic trends.

Globalization has also caught up with Pacific countries with increasing volumes of trade in food commodities, particularly in raw and processed agricultural and fishery products. This trend inherently opens Pacific economies to changes in international market supply and demand and to the volatility of global prices.

Because the above trends will continue amid increasing climate change, their combined threats and impacts on national and regional food security in the Pacific ought to be examined and addressed to ensure sustainable economic growth and stability of the island economies.

Changing Patterns of Food Production and Consumption

A review of food production patterns in the Pacific region reveals three major trends. First, growth in agricultural production generally declined until the mid-1990s, stagnating or slightly rising in most countries from then on. However, the longer-term picture is one of fluctuation rather than continued increase. Second, agricultural productivity has in general stagnated for the last 45 years, and third, per capita agricultural production is declining in all countries, even in (Polynesian) countries with little population growth.

Historically, local harvests of coastal and subsistence fisheries provided most of the animal protein consumed in the region, supplemented with harvests from freshwater fisheries (mostly in Papua New Guinea [PNG]) and a small quantity from aquaculture (in Fiji and PNG). With the expansion of offshore fisheries, the Pacific region experienced a significant increase in landing volumes by both foreign and locally based commercial fleets. However, the catch is offloaded at large processing plants and facilities, with only a minor portion of discards and undersized fish sold in local markets. Fish is consumed at an average of 35 kilograms per capita per year, representing half the average daily protein need. Average consumption is lower in Melanesia, where marine fish are not always available (if at all) in inland or highland areas.

In countries with available data, food consumption trends show a gradually increasing daily intake of calories, with imported food, especially rice and wheat flour, overtaking local foods in the diets of Pacific islanders. This trend of increasing dependence on imported foods has also led to more people, especially in urban areas, relying more on commercial markets for their foods. In addition, the World Health Organization recently reported that the Pacific population's calorie consumption has been increasing, yet nutritional status has decreased, reflecting the change in diets from traditional fare to mainly imported, low-quality foods. This has unequivocally led to the deteriorating health status of Pacific islanders, whose rates of obesity, diabetes, and micronutrient deficiencies are among the highest in the world.

Food security, which was once highly associated with local and traditional agriculture and fishery products, has assumed a different connotation for the Pacific countries, as it has in the rest of the world. It is now closely influenced by trends of rapid urbanization, increasing food importation, and shifts away from traditional and subsistence (food) production systems. Over time, these factors have contributed to the rising vulnerability of food security in the Pacific region. The United Nations Food and Agriculture Organization's Food Import Capability Index (FICI), measured by the proportion of food imports to total food exports, varied across the region but was found to be high in five out of the nine Pacific countries for which estimates were available. These countries include the Cook Islands, Kiribati, Samoa, Tonga, and Tuvalu. Countries with low FICI like PNG show steady improvement in food security, while Fiji has shown a gradual deterioration in food security in the last decade.

Impact of Climate Change and Other Global Phenomena on Food Security

A number of global phenomena and their rising intensity are major sources of threat to food security in the Pacific region. Foremost are the increasing global climate change threats that will produce large impacts on food production systems and food security. Climate change in the Pacific, as predicted by the Intergovernmental Panel on Climate Change (IPCC), will have both direct and indirect effects on food security. The most direct effect, particularly in the smaller atoll countries, will be further reduction of already declining agricultural output per capita as a result of increasing natural disasters and rising sea level in the longer term.

Gains in some crop yields are possible as the climate warms but these may be offset by either wetter or drier conditions. Those conditions will be exacerbated in years of El Niño and La Niña events, which are becoming more frequent with climate change. Crop losses and lower livestock and poultry production are likely to result from excess heat and drought in some places, and oversaturation of soil and physical damage from increased rainfall in others. Coastal and low-lying farms may suffer from seawater inundation and intrusion of saltwater into the groundwater. The large projected impacts

could discourage future investments in large-scale and/or intensive agriculture, which are at present already difficult due to land tenure issues.

Fish stocks may be affected by destruction of coastal habitats and coral death and in the longer term by acidification of seawater. Coastal fisheries, essential in subsistence economies, will also increasingly suffer from overfishing as populations grow, urban areas spread, and fish habitats are lost. Offshore fisheries, mainly of skipjack tuna (the dominant offshore species in the tropical Pacific), are expected to see significant medium-term gains but may suffer a net loss by the end of the century depending on the extent of climate change.

Global financial and food price crises, both of which have occurred since 2007, may also re-emerge with stronger impact, given bigger world populations and continued global economic volatility. The effects of price and economic volatility will exacerbate an already precarious situation due to climate change. Other threats to future food security in the Pacific region include rapid urban population growth, land degradation and declining land productivity, erosion of crop genetic diversity, coastal and coral degradation and declining productivity of fisheries, and breakdowns in traditional social safety nets.

Rethinking Options—A Framework for Improving Food Security in the Pacific

The existing conditions under which improvement of food security in the Pacific DMCs is being pursued amid increasing threats of natural disaster are, with few exceptions, far from desirable. Most of the development partners are seeking to remedy the food security situation by bolstering economic growth through encouragement of more productive and economically efficient activities, especially by an invigorated private sector that can manage the food and related sectors. Development partners also place significant emphasis on strengthening capacities, increasing food production, and developing appropriate policies.

Progress to date has been slow, however, and one pessimistic view is that in Pacific countries the effects of climate change and existing development problems could worsen economic growth in the medium to long term, and trade balances could remain negative. However, even if such conditions continue to prevail, ensuring sustainable food security will remain to be an important objective for Pacific countries.

Regional action on food security in the Pacific is only very recent, with little or no strategy or initiative to address the vulnerability of food security in the face of climate change. The *2010 Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific*, endorsed by the Pacific Island Forum leaders, has for the first time recognized the implications of climate change on food security. Pathways to achieve food security in the Pacific in the face of climate change impacts will involve multiple and simultaneous actions that will (i) promote the local and traditional production and supply base of nutrient-rich foods; (ii) emphasize greater community involvement as part of institutional capacity development for implementing food security and climate change adaptation initiatives; (iii) build climate resilience in cross-sectoral development, as these are important factors for food production and trade; (iv) widen the role of information, education, and communication; and (v) create safety nets and emergency and disaster response systems.

Productivity enhancement and economic growth is seen as an important cornerstone to improving food security in many Pacific countries. This will require effective management of the changing context of agriculture, such as urbanization, decline of interest in agriculture, chronic land disputes, and the uncertainties of adapting food production systems to a changing climate. A greater focus on fish to meet protein shortfalls (while efforts to adapt and improve terrestrial agriculture continue) will also make food security more reliable in the near term, although equitable distribution of fishery products may be a significant challenge.

Institutional capacity development to manage these efforts will be an effective response to improving food security amid the changing climate scenario in the Pacific. However, sufficient domestic capacity for institution building and efficient management of some government roles will

be difficult to maintain in those economies that are too small to support large bureaucracies and multiple institutions. An alternative is for countries to work closely with relevant regional agencies, especially those coordinated by the Council of Regional Organizations in the Pacific. Small core teams in governments could oversee coordination and efficient implementation of climate change and food security programs, while drawing on knowledge, technology, and extension services from the regional organizations. In addition, because most Pacific populations remain rural, following traditional patterns of culture and agriculture, it may be fruitful for governments to provide more leeway for communal cultural practices or non-state mechanisms to take the lead in food security matters and to encourage greater community involvement in decision making.

Harnessing the benefits of **building climate resilience in cross-sectoral infrastructure development** that enhances growth, productivity, trade, and distribution should be an integral part of improving food security in the Pacific region. Investments in climate-resilient infrastructure development, such as land management, water supply, roads, shipping ports, and coastal development, can increase regional and national connectivity, productivity, and food security. Also, the production and provision of adequate safe and nutritious local food should be further supported and encouraged, especially since the region's current free trade approach to development tends to increase imports of processed foods—often calorie-rich and nutrient-poor—which could weaken food security.

Strategies and programs that hinge upon improving **information, education, and communication** have roles to play in ensuring national and regional food security and climate change resilience in Pacific countries. The dissemination of improved data and information will be critical to raise public awareness and understanding of climate change issues and the potential impacts on food production and food security. Such awareness and understanding will be crucial in fostering effective partnerships with local communities for efforts to adapt to, or mitigate, climate change.

An important aspect of enhancing food security in the Pacific is **effective disaster management and emergency response** systems. Often targeted and freely distributed to victims of natural or human-made disasters, disaster and emergency food assistance warrants proper governance and program implementation, including institutional accountability and transparency.

Implications for ADB Assistance

ADB's long-term strategic framework, Strategy 2020, provides significant scope for environmentally sustainable and climate-resilient cross-sectoral and inclusive development to enhance food security among the DMCs in Asia and the Pacific. Its overall support for food security and climate change in the Pacific region represents close synergy with the Pacific leaders' 2010 Framework for Action on Food Security in the Pacific. The interrelationship would mean the need for (i) investments to develop and manage climate-resilient food production systems, infrastructure, and environmental and regulatory measures; (ii) capacity development to enable mainstreaming of food security and climate change into national development plans and programs; and (iii) providing a sustained long-term financing, in coordination with other development partners, for investment in infrastructure and institutions that ensure economic growth in the face of climate change.

ADB assistance along these strategies and priority sectors will need to be supported with policy and legal reform; capacity building of concerned institutions; and/or public awareness and information, education, and communication campaigns. Its support for projects already identified and prioritized in the national development plans of Pacific countries can help build resilient economies that are food secure.

A fundamental aspect of ADB assistance will be improving the coordination of development partner response and helping make global funds readily accessible for Pacific countries. This can be accomplished through a programmatic approach that will help the countries reduce their vulnerability to the impacts and consequences of climate change and pursue a more food secure future.

Introduction

Food security is a complex issue, both nationally and globally. The consequences of food insecurity reached global center stage in 2007–2008 when cereal stockpiles fell to their lowest level in 30 years and prices of staple cereals, such as rice and wheat, rose dramatically, precipitating riots and unrest in more than 20 countries. Prices of staples subsequently declined but rose again; by January 2011, they were higher than in 2007–2008.[1] Although partially eclipsed by the subsequent global financial crisis, the fragile food situation is expected to continue and peak in the mid-21st century.[2] Global food security was, and will continue to be, threatened.

In the Pacific region, effective safety nets have been provided by the strong support system afforded by family members, close relatives, and even the whole community. Food is secured primarily through subsistence farming, fishing and hunting, and trading and selling products. This, however, has changed with recent global trends in national economic development moving from being primarily agriculture-based toward service industries and production of export goods. Food security composition has shifted from mostly locally produced food to a mix of local and imported food. While reducing seasonal food shortages, the increasing dependence on imported food, especially rice and wheat flour, has introduced a new kind of food insecurity and exposed the Pacific countries to the uncertainties of global food production, supply, and cost.

Emerging development trends also contribute to the status of food security in the Pacific countries. These include the (i) countries' inadequate economic performance, aggravated by political instability and ethnic tension; (ii) slower growth in agricultural production than in population, urbanization, and rural-to-urban migration; and (iii) increasing threats of climate change and adverse effects on key production sectors.

This report describes the present state of food security and its contributing factors in the Pacific region, assesses its prospects amid the growing threats and likely impacts of climate change, and describes potential areas for more active assistance, investments, and interventions from the Asian Development Bank (ADB) and other development partners. Chapter 1 presents the general context of food security in the Pacific region, touching on the influences of economic, social, and environmental factors. Chapter 2 describes the region's food security situation in more detail, discussing past trends, current state, and key factors such as local production, population requirements, international trade, and general related constraints. Chapter 3 then presents the growing threats from climate change in the Pacific region and their important impacts and consequences on food security. Chapter 4 highlights a general framework for a renewed approach to simultaneously address climate change impacts and food security vulnerability, and lastly, Chapter 5 enumerates the potential areas where ADB and key development partners can more actively participate to help ensure a more food-secure future for Pacific countries.

General Background

There are about 500 inhabited Pacific islands among 7,500 islands scattered across 30 million square kilometers (km^2) of the tropical Pacific Ocean, divided among 14 independent countries[3] and six French and United States territories. Culturally, the countries are divided into Melanesian (with

1 Food and Agriculture Organization of the United Nations. FAO Food Price Index. www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/ (accessed February 2011)

2 Cribb, J. 2010. *The Coming Famine: Global Food Crisis and What We Can Do to Avoid It*. Berkeley: University of California Press.

3 Reference is usually made to 13 Pacific island independent countries. The new nation of Timor-Leste, at the southwestern tip of the Pacific Ocean (Wallace Line), is the 14th. All these 14 independent countries are ADB developing member countries (DMCs).

Timor-Leste including other Austronesian groups), Micronesian, and Polynesian. According to size and population, there are five groups: Papua New Guinea (PNG), with nearly half a million square kilometers (km^2) of land area; four countries with between 12,000 and 30,000 km^2; five countries of 500–3,000 km^2; five countries with about 200–300 km^2; and tiny Tuvalu (26 km^2) and Nauru (21 km^2). Geologically, there are six mountainous ("high") volcanic countries and nine basically low coral atoll countries, some attaining an elevation of only 1 or 2 meters (Kiribati, the Marshall Islands, and Tuvalu). The high countries are the largest and are all in Melanesia in the west, except Polynesian Samoa. The Federated States of Micronesia (FSM) and Tonga have a few small, fertile volcanic islands within their archipelagos. Most of the low coral atoll countries have exclusive economic zones that extend up to 200 nautical miles, covering large areas of the Pacific Ocean (Table 1).

Population size is broadly related to land area, although there are a few exceptions. PNG has more people than the rest of the region combined. Solomon Islands is second in size but fourth in population; the opposite is true of Timor-Leste. The Marshall Islands and to a lesser extent the Cook Islands are heavily populated for their size (Table 1).

These similarities and differences among the countries influence their food production potential and food security status. The larger high islands tend to have more agricultural potential and "highland" populations living far from the other main food source—coastal fisheries. In contrast, low-lying countries have generally limited agricultural potential and cultures that are more attuned to the sea and fish. Unsurprisingly, populations in the latter countries are among the biggest fish consumers in the world.

Table 1: Tropical Pacific Island Countries, Cultural Group, Land Area, and Population

Rank in Terms of Land Area	High (H)/ Low (L)	Cultural Group, Country	Land Area (km^2)	Sea Area ('000 km^2)	Population (mid-2010)
		Melanesia			
1	H	Papua New Guinea	462,840	3,120	6,744,955
2	H	Solomon Islands	30,407	1,340	549,574
3	H	Fiji	18,273	1,290	847,793
4	H	Timor-Leste	14,874		1,131,612
5	H	Vanuatu	12,281	680	245,036
		Polynesia			
6	H	Samoa	2,785	120	183,123
8	L	Micronesia, Federated States of	701	2,978	111,364
9	L	Tonga	650	700	103,365
11	L	Cook Islands	237	1,830	15,708
13	L	Tuvalu	26	900	11,149
		Micronesia			
7	L	Kiribati	811	3,550	100,835
10	L	Palau	444	629	20,518
12	L	Marshall Islands	181	2,131	54,439
14	L	Nauru	21	320	9,976
		Total Population			**10,130,000**

km^2 = square kilometer
Sources: For land area, except Timor-Leste: Pacific Regional Information System. 2010. *Population at Last Census and Land Area*. www.spc.int/prism/population-at-last-census-a-land-area. For Timor-Leste: *CIA World Factbook* https://www.cia.gov/library/publications/the-world-factbook/geos/tt.html (updated 14 June 2011)
For sea area: Gillett and Preston (1997) and Quartermain (2009).

The ability of the Pacific island governments to govern and manage such matters as food security also varies and is nowhere strong. An ADB review in 2008[4] noted that throughout the region, economic growth has generally remained low, and civil unrest, political instability, and poor law and order remained as hindrances to development. Of the 14 ADB Pacific developing member countries

4 ADB. 2008c. *Working in Fragile Environments: A Midterm Review of the Pacific Strategy (2005–2009)*. Manila.

(DMCs), 10 have fragile and conflict-affected situations.[5] Only the Cook Islands and Fiji have land use policies and plans, which are necessary to optimize sustainable land resources development and management to meet the society's various needs.[6]

Economic Context

The Pacific countries need to generate high, sustained rates of broad-based economic growth from small, narrowly focused economies, which are at the same time vulnerable to external shocks, both natural and human-made. They have to maximize the benefits of globalization, especially lower transport and communication costs and greater opportunities, while managing the costs and risks. With limited financial and human resources, they must deliver public goods and services, most importantly food security.

Across the Pacific region, average annual growth in real gross domestic product (GDP) has been generally increasing since 2005, driven mainly by GDP growth in PNG, Timor-Leste, and Vanuatu (Table 2). However, the growth rate of real GDP was negative in more than half of the Pacific countries in 2009, and in 2010 became positive in all the countries except Tonga. In 2011, it is projected to again increase in 10 of the 14 Pacific countries. Growth rate of GDP per capita across the region is similarly unimpressive, averaging 3.2% in 2010, slightly lower than the 3.4% posted in 2007 and 2008, but is projected to rise to 4.5% in 2011.[7]

Table 2: Growth Rates of Real Gross Domestic Product, Pacific Countries (%)

Country	1995	2000	2005	2006	2007	2008	2009	2010	2011[a]
Cook Islands	(4.4)	3.2	0.0	0.7	9.5	(1.2)	(0.1)	0.5	2.0
Fiji	2.5	(9.3)	0.6	1.9	(0.9)	0.2	(3.0)	0.1	0.5
Kiribati	3.5	4.0	3.9	1.9	0.4	(1.1)	(0.7)	0.5	2.0
Marshall Islands	2.7	(2.3)	0.7	1.6	3.5	(1.6)	(2.1)	0.5	1.0
Micronesia, Federated States of	3.4	2.5	3.0	(0.4)	(2.0)	(2.3)	(0.5)	0.5	1.0
Nauru	…	…	(14.5)	(6.3)	(27.3)	1.0	0.0	0.0	4.0
Palau	…	…	5.9	(3.7)	(0.5)	4.9	(2.1)	2.0	2.0
Papua New Guinea	(3.3)	0.8	3.9	2.3	7.2	6.6	5.5	7.1	8.5
Samoa	6.4	7.0	5.4	0.3	6.6	(3.2)	(1.7)	0.0	2.1
Solomon Islands	10.5	(14.0)	5.4	6.9	10.3	7.3	(1.2)	4.0	7.5
Timor-Leste	…	…	6.2	(5.9)	9.1	12.2	12.7	9.5	10.0
Tonga	2.9	5.3	(1.0)	0.6	(1.4)	2.0	(0.4)	(1.2)	0.5
Tuvalu	(5.0)	3.0	(4.1)	6.6	4.9	1.3	(1.7)	0.0	0.0
Vanuatu	(2.0)	2.8	6.5	7.2	6.8	6.3	4.0	3.0	4.2
Region Average	**(0.6)**	**(1.8)**	**3.1**	**1.5**	**5.0**	**5.3**	**4.2**	**5.2**	**6.3**

… = no available data, ( ) = negative.
a Projections.
Sources: ADB. Various years. *Asian Development Outlook*. Manila.

5 The countries are Kiribati, the Marshall Islands, the Federated States of Micronesia (FSM), Nauru, Palau, PNG, Solomon Islands, Timor-Leste, Tuvalu, and Vanuatu. ADB. 2011b. ADB's Support to Fragile and Conflict-Affected Situations. *Learning Curves*. February. www.adb.org/Documents/Evaluation/Learning-Curves/SES/LC-SES-FCAS.pdf

6 Secretariat of the Pacific Community. 2008. *Land Use Planning in the Pacific*. Policy Brief 3/2008. Noumea. www.spc.int/images/stories/SPPU/land%20use%20planning%20in%20the%20pacific_a4.pdf

7 ADB. 2011a. *Asian Development Outlook 2011: South–South Economic Links*. Statistical Appendix Table A2. Manila.

The economy of Pacific countries consists of both subsistence and cash economies. The subsistence economy dominates, with more than 70% of the population living on their traditional lands, growing food crops, and harvesting forest and marine resources for personal consumption, exchange, and gifting. The cash economy, however, is quickly expanding as rural villagers strive to work outside their farms to earn income for children's education, transport, and other household needs. The narrow economic base and small markets in many of the Pacific countries are only conducive to the development of a few specialized commodities such as copra, cocoa, other cash crops, shells, and handicrafts, or by granting logging companies access to their timber.

Agriculture

Similar to other developing countries, agriculture (including the fishery and forestry subsectors) is the main sector that contributes to economic growth in the Pacific region. It provides income, employment, and livelihood to most Pacific islanders, and hence plays a significant role in ensuring food security, promoting income growth, and improving general welfare.

The annual growth of the total agriculture sector shows mixed positive and negative trends over time. In countries for which data are available, growth in the sector slowed but generally remained positive from the 1990s to the 2000s, except for modest improvement in Kiribati, Solomon Islands, and Tonga. Fiji, Samoa, and Tuvalu all posted negative growth in agriculture in the 2000s (Table 3).

The contribution of the sector to GDP generally declined between the 1990s and the 2000s. During 2000–2008, agriculture's share of total GDP was more than 30% in PNG, Solomon Islands, and Timor-Leste; about 27% in Tonga; and 24% in Kiribati. In the other Pacific countries, its contribution ranged from 11% in Nauru to 17% in Tuvalu (Table 3). Noticeably, the large, volcanic states of Melanesia tend to have GDPs with a big agriculture component.

Table 3: Agriculture Growth and Share in Total Gross Domestic Product in Pacific Countries

Country	Annual Growth Rate of Agriculture (%)		Share of Agriculture in Total GDP (%)		Share of Fishing in Total GDP (%)[a]	
	1990s	2000–2008	1990s	2000–2008	Official	Re-estimated (year)
Cook Islands	8.3	3.2	15.3	12.4	6.3	**1.4 (2007)**
Fiji	1.0	(0.9)	17.8	14.2	1.9	**1.7 (2007)**
Kiribati	(2.4)	1.3	25.5	24.3	3.5	**53.4 (2007)**
Marshall Islands	…	…	…	…	0.4	**26.7 (2007)**
Micronesia, Federated States of	…	…	…	…		**10.0 (2006)**
Nauru	…	…	…	11.4	10.2	**4.6 (mid-2000s)**
Palau	…	…	4.7	3.5	2.2	**6.1 (2006)**
Papua New Guinea	4.8	1.6	31.4	35.4	2.7	**3.1 (2006)**
Samoa	1.9	(2.4)	19.5	12.9	5.4	**6.2 (2007)**
Solomon Islands	2.3	4.9	31.0	33.0	6.0	**6.8 (2007)**
Timor-Leste	2.4	0.9	33.8	31.1	…	**…**
Tonga	0.3	1.6	33.6	26.8	4.2	**5.1 (2009)**
Tuvalu	1.3	(4.7)	23.5	16.8	8.2	**10.3 (2002)**
Vanuatu	**3.0**	**1.9**	**17.2**	**14.9**	**0.8**	**1.3 (2007)**

… = no available data, ( ) = negative number, GDP = gross domestic product.
a Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Manila: ADB.
Source: ADB. 2009b. *Key Indicators for Asia and the Pacific 2009*. Manila.

Fisheries

Official figures show that the contribution of fishing to GDP reached a maximum of only 10% (Table 3). However, these do not account for subsistence fishing and sometimes include inconsistencies. A careful examination of all sources of catch re-estimated fishing contribution to GDP to be more than half the total GDP of Kiribati and a quarter of that of the Marshall Islands. In the other countries, the

contribution was 10% maximum, but nearly all cases showed the re-estimate as larger than the official figure.[8]

Beyond the fishing sector, there are postharvest jobs and other forms of revenue, especially expenses of locally based fleets and access fees for offshore foreign tuna fleets. In 2000, "[i]ndustrial-scale tuna fishing provide[d] large benefits to [Forum Fisheries Agency] Pacific island member economies: $60 million in access fees, 25,000 jobs, close to $130 million in expenditures by locally based vessels, and a host of other benefits."[9]

Fishery-related revenue in each country form only a small part of GDP, except in Kiribati and Tuvalu, where access fees made up about 43% of GDP in 2003. At that time, the annual Pacific tuna catch was valued at more than $3 billion, and access fees amounted to 6% of the total.[10] Because government revenues are not usually counted as part of GDP in the Pacific,[11] the total contribution of fisheries may be highly undervalued in these estimates. An economic analysis of 2003 worldwide data[12] showed that for Oceania, which includes the Pacific countries, regional fish production value was more than $5 billion, and indirect and induced effects accounted for another $21 billion, for a total supported output of more than $26 billion.

Trade

Commodity exports of Pacific countries are the main sources of revenue used to purchase basic needs items, including imported food. But exports have declined over time. Table 4 compares exports and food imports in value terms, and clearly shows deteriorating terms of trade.

The majority of exports of Pacific countries are based on natural resource: agricultural (copra, coconut oil, cocoa, fruit, kava), marine (fresh and canned fish, pearls, seaweed), forestry (timber), and mining (gold). Most of the countries grow and export almost the same commodities, limiting interisland trade. Market access, quality assurance, consistency of supply, and deteriorating marketing infrastructure—including postharvest storage and transport—have been identified as constraints to expanding export earnings.

Table 4: Trends in Food and Fish Trade, Pacific Countries

	1960s	1970s	1980s	1990–1994	1995–1999	2000–2004	2005–2008
Food Excl Fish							
Value ($ '000)							
Import	40,274.3	139,747.8	261,475.8	353,281.8	402,512.6	396,174.8	586,843.3
Export	86,082.8	220,333.7	366,501.0	371,035.0	528,857.2	433,969.0	554,933.7
Growth Rates (%)							
Import	9.0	16.8	2.7	4.9	0.0	5.3	12.9
Export	7.8	21.9	0.6	2.7	4.1	2.9	8.4
Fish							
Value ($ '000)							
Import	...	39,893.3	59,160.3	68,449.8	52,124.0	46,954.0	63,645.5
Export	...	45,014.5	73,379.7	131,217.4	182,654.6	250,303.2	331,643.0
Growth Rates (%)							
Import	...	22.6	4.9	(0.1)	(9.6)	15.6	1.8
Export	...	46.4	10.2	8.2	5.8	11.4	(0.3)

... = no available data, ( ) = negative number.
Source: FAOStat. http://faostat.fao.org

8 Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Manila: ADB.
9 Gillett, R., et al. 2001. Tuna: a Key Economic Resource in the Pacific Islands. *Pacific Studies Series*. Manila: ADB.
10 Greenpeace. 2004. *Tuna: The Pacific's Most Valuable Asset*. Suva: Greenpeace Australia Pacific. Fiji. www.greenpeace.org/raw/content/australia/resources/reports/overfishing/tuna-pacfic-s-most-valuable-a.pdf
11 Johann Bell, Secretariat for the Pacific Community, personal communication.
12 Sumaila, U.R., et al. 2011. Global Fisheries Economic Analysis. In V. Christensen and J. Maclean, eds. *Economic Approaches to Fisheries: A Global Perspective*. New York: Cambridge University Press.

Social Context

The social aspect of food security includes factors such as population, migration, and urbanization. The mid-2010 population of Pacific countries was 10.1 million (Table 1) and is reported to be increasing at an average annual rate of 1.9%. The highest population growth rates are in Melanesia, reaching 2.7% in Solomon Islands and 2.5% in Vanuatu, and the lowest are in Polynesia (Table 5). Net migration data shows that about 14,000 people leave the countries annually. Overall, Melanesia is expected to grow by 1.9% per year to 2030; Polynesia, by 0.7%; and Micronesia, by 1.0%. Emigration accounts for much of the low population growth rates in Polynesia and Micronesia.

The Role of Migration

Migration has long been a feature of Pacific existence. The original islander settlers occupied the region gradually from west to east, and migrated mainly because of increasing population pressures and exhaustion of resources in their original island base. Most migration from Pacific countries to western countries (mainly New Zealand) has been for economic reasons; however, the almost immediate effect has been to relieve increasing population pressure at home. For example, without migration to New Zealand, Samoa today would have nearly double its mid-2010 population of 183,000 people.[13] Even so, the proportion of people living under the basic needs poverty line in Samoa increased from 15% in 1997 to 27% in 2008. Without migration, Pacific populations would increase by around 50% in 20 years. For Samoa, this could mean a 2030 population of more than thrice its current number.

In addition, the existing benefits of remittances from temporary and permanent migrants are extensive. Much of the inflow is spent on consumer goods, however, and the potential benefits of remittances, if managed safely through official channels and used more for savings and investment, appear even greater.

Table 5: Projections of Demographic Indicators in Pacific Countries

Cultural Group, Country	Estimated Population, Mid-year			Net Number of Migrants	Annual Population Growth Rate (%)[a]	Urban Population at Last Census (%) (Census Year)
	2030	2035	2050	2010		
Melanesia	**12,108,329**	**13,134,695**	**16,116,244**	**(6,489)**		
Fiji	946,320	977,586	1,060,706	(6,489)	0.5	51 (2007)
Papua New Guinea	9,899,549	10,763,066	13,271,057	0	2.1	13 (2000)
Solomon Islands	876,394	969,920	1,245,774	0	2.7	16 (1999)
Vanuatu	386,066	424,122	538,707	0	2.5	24 (2009)
Micronesia	**357,213**	**368,561**	**400,779**	**(2,733)**		
Federated States of Micronesia	121,051	124,059	137,554	(1,633)	0.4	22 (2000)
Kiribati	137,471	144,636	163,266	(100)	1.8	44 (2005)
Marshall Islands	62,414	62,742	61,217	(1,000)	0.7	65 (1999)
Nauru	13,672	14,390	16,283	0	2.1	100 (2006)
Palau	22,604	22,734	22,459	0	0.6	77 (2005)
Polynesia	**339,382**	**347,410**	**363,866**	**(4,999)**		
Cook Islands	16,261	16,302	15,977	(98)	0.3	72 (2006)
Samoa	197,689	202,039	209,740	(3,050)	0.3	21 (2006)
Tonga	111,731	115,032	123,008	(1,711)	0.3	23 (2006)
Tuvalu	12,488	12,800	13,858	(98)	0.5	47 (2002)
Total	**12,803,711**	**13,849,627**	**16,879,149**	**(14,122)**		

( ) = negative number

a These numbers include births, deaths, and migration.

Source: Pacific Regional Information System, updated September 2010. www.spc.int/prism/data/social

13 This number is from the Pacific Regional Information System (www.spc.int/prism/population-at-last-census-a-land-area). However, the Central Intelligence Agency *World Factbook* gives a figure of 220,000. https://www.cia.gov/library/publications/the-world-factbook/geos/ws.html

Urbanization[14]

Across most Pacific countries, the growth rate of urban populations has been increasing faster than that in rural areas for at least 3 decades. Exceptions are the FSM and Palau, where urban populations have declined due to increasing emigration. Table 5 shows the proportion of urban dwellers in Pacific countries in various recent census years. High levels of urban residents are commonly in Micronesia and Polynesia; only Fiji has a high level in Melanesia. In 2007, urban populations in Melanesia were expected to double within 25 years, posing "serious challenges for planning, land use, water and sanitation, housing and general infrastructure, as well as some serious rethinking of current social, health and employment policies." The same of course is true, and more importantly so, for food security.

The majority of Pacific islanders remain rural but not greatly so. The average proportion of urban dwellers across the region was about 25% in 2007; 46% when dominant PNG is removed from the total. In terms of numbers, most urban residents are in Melanesian cities and towns (1.58 million in 2007), while the highest proportions of urban residents are in Micronesia, where the Marshall Islands, Nauru, and Palau have more than half their populations in towns. Of the Polynesian countries, only the Cook Islands has a large urbanization rate. More recently, the Secretariat of the Pacific Community projects, based on 2010 Pacific populations, that rural population will grow by 34% by 2035, from about 7.5 million to 10.0 million. However, urban population is projected to more than double to 107% of 2010 levels, growing from roughly 2.5 million to 5.0 million.[15]

Rural-to-urban migration is largely by young adults. The average age in urban areas is further lowered through higher birth rates because there are more urban women of reproductive age. This trend appears to be true in much of the urban Pacific, most notably in Kiribati, the Marshall Islands, PNG, Solomon Islands, and Vanuatu.

The effect of urbanization on living conditions can be gauged by the resulting population densities. For example, in 2005, Kiribati had an average population density of 127 persons/km^2; in the South Tarawa urban area, it was 2,558 persons/km^2; and on the South Tarawa islet of Betio, the country's main commercial area and port, it was 10,400 persons/km^2—twice that of Hong Kong, China, and Singapore. Similarly, in Vanuatu's main town, Port Vila, the urban population in 2007 averaged about 1,730 persons/km^2, but varied from 33 persons/km^2 in Malapoa Point to an outstanding 31,000 persons/km^2 in Seaside Tongoa-Futuna.

To date, only a few countries have policies addressing urban development and management. For example, Fiji and PNG have policies aimed at reducing urbanization by promoting income opportunities and providing necessary services in the rural areas.[16]

Environmental Context

The Pacific countries are mostly characterized by their small physical size and geographical remoteness, fragile biodiversity, and a limited natural resource base. Their high-population urban centers and resource-poor rural communities both contribute to, and are confronted by, the overharvesting of natural resources and environmental degradation. Most, if not all, Pacific countries are also confronted with extraordinary circumstances with respect to climate change. They face dire and immediate consequences—such as sea-level rise, stronger storms, more frequent floods and droughts, and the changing distribution of disease vectors—that are markedly disproportionate to their contribution to global greenhouse gas emissions. The impacts of climate change on food production; use of land,

14 Haberkorn, G. 2008. Pacific Islands' Population and Development: Facts, Fictions and Follies. *New Zealand Population Review*. 33/34. pp. 95–127.

15 Bell, J. 2010. *Climate Change, Fisheries and Aquaculture in the Pacific: Adaptations for Food Security, Livelihoods & Economic Growth*. Noumea: Secretariat of the Pacific Community.

16 Simatupang, P., and E. Fleming, eds. 2001. *Food Security in Southwest Pacific Island Countries*. Proceedings of a workshop held in Sydney, Australia, 12–13 December 2000. Bogor: Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre). www.uncapsa.org/publication/cg40.pdf

coastal, and marine resources; damage to infrastructure and water resources; and risks to human health can compromise the prosperity, stability, and security of Pacific countries, thereby creating significant development challenges for the region. This section describes in general terms the physical environment against which the issue of food security in the Pacific region is analyzed in this paper. The threats and impacts of climate change on food security are discussed in more detail in Chapter 3.

In the mainly subsistence-based economies of Pacific countries, the "natural capital" provided by the environment is all important and has been included in recent poverty assessments, along with physical, human, social, and financial assets.[17] Across the countries' diverse environmental characteristics, the three most pervasive and serious local threats are habitat destruction, pollution from land-based sources, and overharvesting of resources.

Forest ecosystems are an essential component of the Pacific environment. Besides their ecological functions, forests are sources of food, income, medicine, fuel, and building materials and, therefore, are linked to the overall food security of communities, especially those near these resources. Wild harvests of edible nuts, fruits, plants, and meat from the forests form a significant source of food for Pacific island people.

The Pacific region has about 34 million hectares of forest, of which 25 million hectares of closed canopy forest are accessible for commercial utilization. Fiji, Solomon Islands, and Vanuatu have significant forest areas, but logging has changed the extent of these resources substantially.[18] Vanuatu once possessed valuable stands of sandalwood that have largely disappeared, and efforts are being made to redevelop them. Fiji's timber resources are now largely made up of introduced pine and mahogany plantings. Solomon Islands still has very large areas of native timber. However, with logging being the government's main revenue-generating base, it is often claimed that the forests will be depleted within 10–15 years.

Pacific island culture and survival are based on the present diversity of plants and animals, which is increasingly threatened: "urbanization and western development, deforestation, forest degradation, and loss of agrobiodiversity are proceeding at frightening rates, along with erosion of Pacific Islands' sophisticated knowledge systems."[19] A study of 140 coastal plant species across the tropical Pacific confirmed their many direct human uses and specific ecological services: "providing shade, as animal and plant habitats; protection from wind, erosion, flood, and saltwater incursion; land stabilization, protection from desiccating effects of salt spray, soil improvement and mulching; and as animal food or links in important terrestrial and marine food chains."[20] These services are of obvious importance for food security in Pacific communities.

The majority of Pacific communities depend on marine and coastal ecosystems for their livelihood and sustenance. However, habitats are lost or destroyed by destructive fishing practices (such as coastal trawling, use of dynamites or poisons, and indiscriminate netting), poor agricultural land use resulting in increased erosion and sedimentation, inappropriate coastal development, and industrial wastewater. Organic pollutants from sewage, nutrient pollution from fertilizer runoff, urban runoff, and dispersed pollutants are also critical threats. Land-use practices that create erosion, or eat up mangroves and smother seagrass beds, reduce coastal ecosystem health and impair local productivity. Poorly designed development projects (e.g., tourism, roads, housing, urban centers, and aquaculture) also destroy coastal habitats and limit livelihoods that depend on ecosystem productivity. Coastal fish stocks, along with those of corals, sea grasses, and mangroves, are threatened by ever-increasing pressure from growing human populations, especially around urban areas where pollution and habitat destruction add to the effects of overharvesting and overutilization.

17 Steele, P., G. Oviedo, and D. McCauley, eds. 2006. *Poverty, Health, and Ecosystems: Experience from Asia*. Gland, Switzerland: International Union for Conservation of Nature and Manila: ADB.

18 Duncan, R., and H. Nakagawa. Undated. *Obstacles to Economic Growth in Six Pacific Island Countries*. Online access. siteresources.worldbank.org/INTDEBTDEPT/Resources/468980-1206974166266/4833916-1206989877225/DuncanNakagawaObstacles.pdf

19 Thaman, R.R. 2008. A Matter of Survival: Pacific Islands Vital Biodiversity, Agricultural Biodiversity and Ethno-Biodiversity Heritage. *Pacific Ecologist*. January.

20 Thaman, Matter of Survival.

Freshwater fisheries and water bodies are important in the larger island countries and have been subject to the introduction of exotic species in the recent past. Freshwater aquaculture, nearly all using the introduced fish tilapia, has potential in some parts of the Pacific and exists on a small scale. However, the possible detrimental effect of tilapia farming on local biodiversity may hinder expansion. As such, expansion of tilapia farming will require careful conservation measures, beginning with feasibility and risk assessments and decisions on zoning. The principles also apply to the introduction of new or improved crop plants and tree species.

In order to reconcile the issues of biodiversity and food security, a comprehensive study across all commodities based on introduced species that promise to help provide food security in the region will be necessary.[21] At present, nearly all options to increase aquatic food production run counter to the growing number of global agreements on biodiversity conservation. There is therefore a need for serious dialogue between all relevant agencies that will lead to coherent policies and practices. In the Pacific, a stalemate between food security and biodiversity arrangements could set back the attainment of food security at a time when it is most threatened.

21 Bell, personal communication.

Food Security: Current Status and Factors

"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." (World Food Summit, 2009)

While the United Nations Food and Agriculture Organization (FAO) outlook on world cereal production can put policy makers fairly at ease, world hunger statistics raise concerns over food security. The first Asia–Pacific Economic Cooperation (APEC) Ministerial Meeting on Food Security held in Niigata, Japan in October 2010 noted that, although there were no significant shortfalls in global production and supply in the last two food crises, the underlying cause of chronic world hunger is the lack of access to food by the poor and vulnerable groups in society. In the FAO's latest estimates, the number of undernourished people in the world exceeded 1 billion in 2009 for the first time in human history, although this declined to 925 million in 2010. The FAO estimates that the world population will reach 9.1 billion in 2050, such that food production should increase by at least 70% to ensure sufficient supply.[22]

In the Pacific region, the issue of food security has been actively discussed in various international and regional forums, the most recent of which was the April 2010 Pacific Food Summit in Port Vila, Vanuatu. One important output of this summit was a design framework to address food security in the region: *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific*.[23]

Similar to most other developing and some developed countries, the foremost sector that contributes to economic growth and food security in Pacific countries is agriculture. The geophysical nature of the region, however, poses great challenges to the agriculture sector's efforts to perform satisfactorily at all times. The fragile and vulnerable natural resource base is prone to a wide range of natural disasters, including potentially devastating consequences of extreme climatic events that severely disrupt food production and supply, disrupt livelihoods, displace people, and reduce access to food.

This chapter presents the past trends and current state of major components of food security in the Pacific region, describes the role of international trade in food, and briefly discusses the factors that will affect the region's growth and opportunities for sustainable expansion.

Food Production and Consumption

Agriculture (Crops and Livestock)

Production. Traditional and subsistence agriculture or agroforestry has long provided the bulk of Pacific islanders' diets and is based on a combination of tree crops (e.g., coconut, breadfruit, and pandanus) and taro or other root crops, which are the staple foods. The crop combinations vary widely from island to island depending on topography, rainfall pattern, and markets. The systems have diversified over time with additions of fruit trees and other crops, such as sweet potatoes, limes, and vegetables. The major commercial agricultural commodity in terms of area coverage and use, including export, is

22 ADB. 2011d. Food Security in the Asia–Pacific. *Finance, Food, and Fuel Monitor*. 29 July. https://wpqr1.adb.org/LotusQuickr/3f-cop/PageLibrary482577830046AAF3.nsf/h_153E9E9F524864A7482577830046BCA1/69A2CE3777CFAE16482578DC001DB29F/$file/FinCom%2020.pdf

23 Food Secure in the Pacific. 2010. *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific.* www.foodsecurepacific.org/documents/FINAL%20TOWARDS%20A%20FOOD%20SECURE%20PACIFIC_June1.pdf

the coconut. In recent years, its demand for biofuel production has also been increasing. Root crops, principally taro, rank next in importance. Sugarcane is also an important commercial crop in the region, and is most extensively cultivated in Fiji and Papua New Guinea (PNG). A variety of fruits and vegetables are also grown in the region but more so in the Melanesian countries (e.g., Fiji, PNG, and Samoa).

Table 6 shows the long-term food crop and livestock production index for Pacific countries, and Appendixes 1 and 2 present the same for the regional totals. The production indexes show a general decline until the mid-1990s, stagnating or slightly rising in most countries from then on. The largest recent reduction in the food production index was in the Cook Islands, due to a decline in both area and yield of major crops like coconuts, roots, and tubers, including cassava and sweet potatoes.

Fiji's total crop production has fallen due to the decline in sugarcane production, which was associated with long-term uncertainty about renewal of land leases. Coconut production in the country (and in the Pacific region as a whole) also declined sharply until the 1990s and stagnated at about 140,000 tons per year thereafter due to a depressed world price of copra, declining yield of aging trees, and inadequate storage and shipping capacity.

Agricultural production in some countries has risen in the past decade. For example, major crop production in Kiribati, PNG, Samoa, and Tuvalu has increased with expanded areas and improved yields, although the longer-term picture is one of fluctuation rather than an increasing trend. PNG's cassava production more than doubled, while its sugarcane production rose from about 7 tons in the 1960s to about 450,000 tons in the 2000s. The recent increase in Kiribati's food crop production comes primarily from increased production of coconuts, fruits, and vegetables, the latter increasingly targeted for export.

Increases in food crop production in the Pacific have come mainly from area expansion rather than from increases in yield. This is primarily the case for oil palm, maize, and almost all the root crops including taro, yams, cassava, sweet potatoes, and potatoes. In general, agricultural productivity (yield per hectare) in the region has been relatively stable, showing small increases or decreases over the past 50 years. In comparison, the long-term rate of annual agricultural productivity growth in Australia and the United States, which have capital-intensive agriculture, has been around 2%.[24]

The growth rate figures suggest three emerging trends in crop production in the Pacific region. The first relates to technological progress that seemingly has not yet occurred akin to that in Asia, even for the staple grains. Second is the rapid area expansion for crops with potential for biofuel production (e.g., oil palm, cassava, and maize). However, there has seemed to be reinvigorated interest in traditional staple foods like taro, sweet potatoes and potatoes, especially in 2005–2008 when the food price crisis took place. Third, while production of most staple crops is increasing on a regional basis, per capital agricultural production is declining in all countries, even in Polynesian countries with little population growth (Appendix 2). These trends raise food security concerns in Pacific societies, given the large proportion of rural population who depend on agriculture for their livelihoods.

Livestock are not widely produced in many Pacific countries. In countries reporting livestock data, production indexes in this subsector have been increasing for all livestock products, although the rates of annual production growth generally slowed down over time (Appendixes 1 and 2). Only poultry meat production has grown consistently in the last half century. All production of red meat livestock (cattle, buffalo, sheep, and goat) were reported with negative growth rates. Pigs are raised on a free-range basis and do not appear in the statistics.

Consumption. Available data on overall food consumption in the Pacific shows a gradually increasing daily intake of calories, although significant proportions of undernourished people are reported from Solomon Islands, Timor-Leste, and Vanuatu (Table 7).

Imported rice and wheat flour have spread quickly around the Pacific and now appear to be irreversibly entrenched in Pacific diets. In PNG, for example, rice was virtually unknown until the late 1960s. Then, in the highlands, work on the booming coffee plantations brought cash income to

24 Australian Agency for International Development. 2009. *Tracking Development and Governance in the Pacific.* Canberra.

Table 6. Food and Livestock Production Performance of Pacific Countries

Countries	Food Production Index (base 1999–2001)						Net Per Capita Production Index (base 1999–2001)						Livestock Production Index (base 1999–2001)					
	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008
Cook Islands	164.2	191.7	150.2	100.2	96.4	68.9	135.0	152.0	133.2	89.0	90.4	74.6	32.1	51.3	68.9	51.8	91.6	80.6
Fiji	66.0	73.2	93.2	103.0	100.4	96.9	115.9	103.1	108.3	111.6	103.0	94.9	35.1	55.7	79.9	99.0	102.0	104.5
Kiribati	61.0	68.4	89.0	79.6	96.4	111.5	135.7	119.2	120.9	90.4	102.0	104.8	66.8	70.5	77.4	83.8	88.2	114.0
FSM	…	…	…	…	100.0	100.1	…	…	…	…	99.4	98.1	…	…	…	…	100.0	100.1
Nauru	58.1	70.3	87.8	97.4	99.6	100.9	105.1	102.3	107.4	101.8	99.6	100.6	34.6	49.3	73.2	95.2	99.6	100.3
Papua New Guinea	44.1	55.8	70.4	81.6	92.2	106.1	100.3	105.8	105.7	100.6	99.4	96.6	44.0	54.8	69.2	82.4	93.0	110.0
Samoa	91.6	101.4	117.6	84.4	97.6	104.0	128.4	120.6	133.0	91.6	100.8	101.3	42.2	48.1	77.0	94.0	93.2	104.3
Solomon Islands	41.8	55.7	80.1	83.6	99.8	107.4	127.4	122.2	126.0	104.4	108.2	97.8	37.7	73.8	88.6	88.2	92.6	108.5
Timor-Leste	61.6	74.7	79.6	111.4	106.8	111.8	83.0	90.8	97.9	106.8	101.4	93.8	86.8	79.3	59.8	108.4	113.8	121.1
Tonga	123.1	128.0	108.0	104.0	96.8	102.3	145.8	131.0	112.5	106.6	97.0	101.3	34.7	59.5	88.6	93.4	93.0	96.8
Tuvalu	97.0	80.1	92.5	96.0	92.0	107.4	143.9	103.9	108.9	97.6	92.0	105.9	23.0	24.9	39.1	71.6	89.6	104.0
Vanuatu	67.7	79.8	97.1	99.4	109.4	101.3	174.2	152.1	142.1	119.4	115.8	92.5	40.6	61.7	69.0	93.6	101.2	92.6

… = no available data, FSM = Federated States of Micronesia.
Source: Asian Development Bank.

Table 7: Food and Nutrition Security and Poverty Status in the Pacific Region

Countries	Food Consumption (kcal/capita/year)[a]				Proportion of Population below Minimum Level of Dietary Energy Consumption (%)			Food Deficit of Undernourished Population (kcal/person/day)				< 5 Years Mortality (%)[b]	Proportion of Population below the Poverty Line	
	1990	1995	2000	2005	1990–1992	1995–1997	2003–2005	1990-1992	1995-1997	2000-2002	2004-2006	2007	National[c]	Year
Cook Islands	…	…	…	…	…	…	…	180	170	160	40	18	28.4	2008
Fiji	2,592	2,728	2,872	3,001	8	5	< 5	…	…	…	…	18	34.3	2007
Kiribati	2,589	2,813	2,803	2,854	8	5	5	190	180	180	140	63	38.0	1996
Marshall Islands	…	…	…	…	…	…	…	…	…	…	…	54	20.0	1999
FSM	…	…	…	…	…	…	…	…	…	…	…	40	36.7	2007
Nauru	…	…	…	…	…	…	…	…	…	…	…	30	…	
Palau	…	…	…	…	…	…	…	…	…	…	…	10	24.9	2008
PNG	…	…	…	…	…	…	…	…	…	…	…	65	39.6	2002
Samoa	2,614	2,487	2,736	2,769	9	10	< 5	180	180	160	210	27	20.3	2004
Solomon Islands	1,984	2,328	2,264	2,433	25	13	9	220	190	190	130	70	22.7	2007
Timor-Leste	2,268	2,355	2,276	2,169	18	13	22	230	210	210	230		41.9	2001
Tonga	…	…	…	…	…	…	…	…	…	…	…	23	22.3	2004
Tuvalu	…	…	…	…	…	…	…	…	…	…	…	37	25.9	2006
Vanuatu	2,496	2,541	2,630	2,752	10	10	7	200	200	190	150	34	15.9	2008

… = no data available, FSM = Federated States of Micronesia, kcal = kilocalorie, PNG = Papua New Guinea.

a Based on available food supply.

b Probability of dying between birth and 5 years per 1,000 live births.

c Refers to percentage of population below the basic needs poverty line. It includes not only food but also a basket of other essential non-food expenditures (goods and services) that each household or individual needs to maintain a basic standard of living.

Sources: Asian Development Bank; FAO Stat. www.faostat.fao.org

local laborers, which enabled them to buy rice to overcome seasonal food shortages.[25] Rice is now so embedded in the diet of the population that the country's medium-long term strategic plan of action (2000–2015) includes becoming self-sufficient in rice production.

Demand for meats in the region increased on average by 1.7% per year during 1972–2003 and this trend was expected to continue.[26] Most of the strong demand for meats, driven by population increases, increases in disposable incomes, rapid urbanization, and the growth of the tourism industry, is met through imports. There are opportunities for import substitution in this subsector through higher domestic production, but the subsector is greatly dependent on availability and accessibility of animal feeds, which are mostly imported and relatively expensive.

The present food consumption situation in the Pacific is the combined result of population growth, decline of sustainable traditional farming, urbanization, and increasing preference for cheaper imported foods. Although poverty is increasing in all countries except Vanuatu, food consumption in terms of calories has been slowly increasing, at least in the six Pacific countries for which data are available (mainly Melanesian countries).

Fisheries

Production. Some Pacific countries like Kiribati, the Marshall Islands, and Tuvalu are atolls with porous, sandy soils, and therefore have very limited potential for crop agriculture. These countries rely on the sea for food and sources of economic growth. Subsistence fisheries provide the people with a variety of fish products as a primary source of protein. Other marine products, particularly tuna, are also bountiful for the local commercial and export markets.

The most recent available data for the Pacific region shows that total fishery and aquaculture production in 2007 was 1.3 million tons (Table 8). The fisheries are divided into offshore and coastal, which includes subsistence—the catch kept for home consumption or given to friends—and commercial fishing in inshore areas. Offshore production is from huge pelagic, mainly tuna, fisheries, consisting of commercial fleets based either in one of the Pacific islands (locally based) or outside the region (foreign-based). Vessels of both fleets offload their catch at large plants or processing facilities, although a minor part of the locally based offshore catch, consisting mainly of discards and undersized fish, is sold locally.

Table 8: Fishery Production in Pacific Countries, 2007 (tons)

	Coastal Commercial	Coastal Subsistence	Offshore		Freshwater	Regional Total
			Locally Based	Foreign-Based		
Fishery category totals	39,001	101,921	396,034	864,685	23,440	
Totals adjusted for duplicate offshore fishing (–10%)	39,001	101,921	1,134,647		23,440	1,299,029

Note: Table does not include aquaculture due to difference in units (weights and pieces). Timor-Leste is not included in totals.
Source: Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Table 25.1. Manila: ADB.

25 Igua, P.B.K. 2001. Food Security Strategies for Papua New Guinea. In *Food Security in Southwest Pacific Island Countries*. Proceedings of a workshop held in Sydney, Australia, 12–13 December, 2000. Bogor: CGPRT Centre. www.uncapsa.org/publication/cg40.pdf

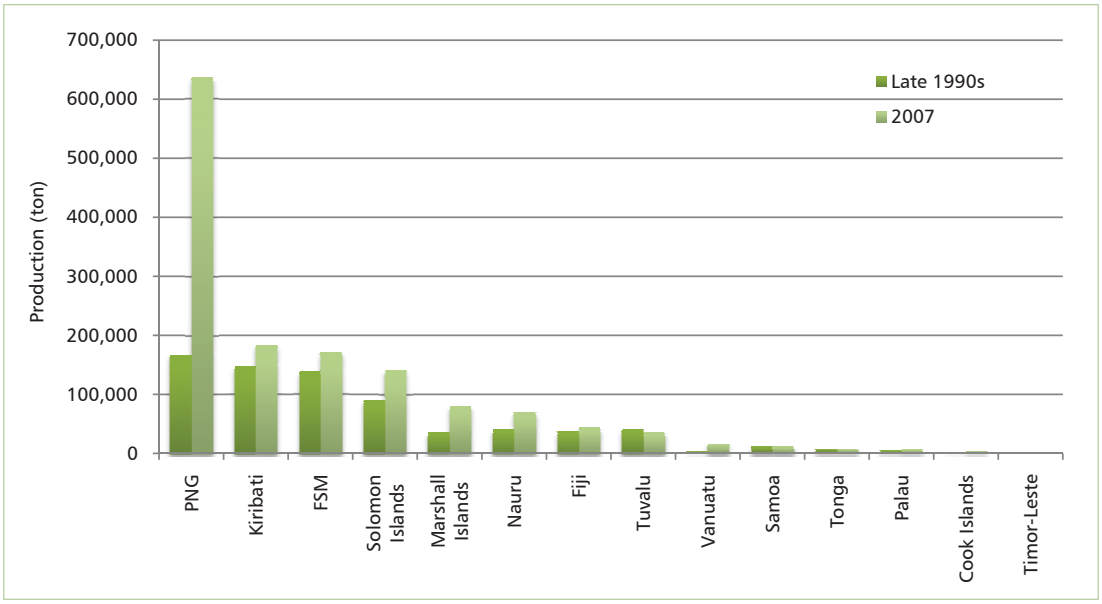
26 Secretariat of the Pacific Community. 2009. *Livestock in the Pacific*. Policy Brief 9/2009. Noumea. www.spc.int/images/stories/SPPU/policy_brief_9.pdf

Substantial increases in fishery and aquaculture production were reported for most Pacific countries during 1999–2007 (Figure 1). The increases were nearly all in the offshore area and almost entirely tuna (Figure 2), while coastal fishery production showed little change, implying that coastal (commercial and subsistence) fisheries are fully exploited. This has an important bearing on food security because coastal fisheries are the source of virtually all domestic fish consumption.

The importance of tuna should be highlighted: it both enhances food supply and provides income and employment in the Pacific region. Total catch (tuna plus bycatch) of the locally based offshore fleet in the Pacific was about 44,000 tons in 2007. Assuming that 10% of this was marketed locally, this meant that 4,400 tons of fish was made available for food use. In Fiji, Suva in particular, the amount of domestically marketed catch from locally based offshore vessels suggests an annual supply of fish of 10.4 kilograms (kg) per capita. In Tonga, the amount of bycatch and non-exported fish from locally based offshore vessels is about 10.7 kg per capita annually.[27] Domestically available fish from industrial tuna operations is projected to grow in the future with periodic gluts and scarcity because of the geographic mobility of the seiners.

The quantity of fish available for domestic consumption may increase following a recent decision by the eight tuna-fishing countries that are parties to the Nauru Agreement (Fiji, Kiribati, the Marshall Islands, Nauru, Palau, PNG, Solomon Islands, and Tuvalu) to ban the discarding of undersized fish at sea. As such, there will be large amounts of fish for local markets in ports where transhipping of tuna takes place (e.g., Honiara in Solomon Islands). Storage and distribution mechanisms will be needed for these fish to reach inland as well as nearby coastal populations.[28]

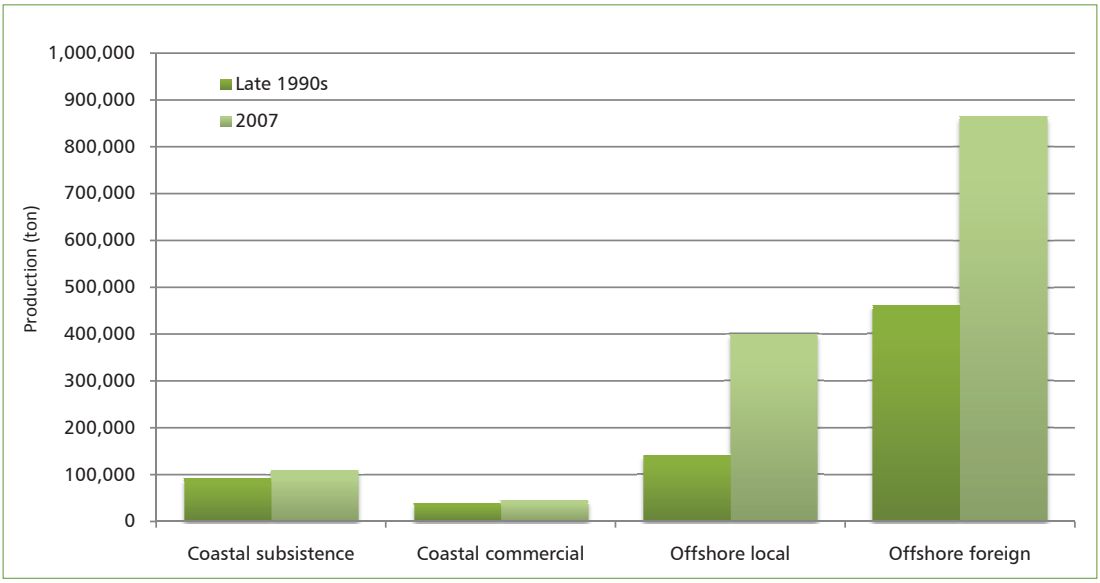
Figure 1: National Fishery Production in Pacific Countries, 1999 and 2007 (tons)



FSM = Federated States of Micronesia, PNG = Papua New Guinea.
Source: Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Manila: ADB.

27 Gillett, Fisheries in the Economies.
28 Bell, personal communication.

Figure 2: Fishery Production in Pacific Countries by Category, 1999 and 2007 (tons)



Source: Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Manila: ADB.

Freshwater fisheries are significant only in the large Melanesian countries, with PNG accounting for three-quarters of the total 23,000-ton production in 2007, with the remainder in Fiji and Solomon Islands. Table 9 shows the volume harvested from aquaculture (or fish farming) production in the Pacific region. Tilapia is by far the most important cultured commodity for local food. However, aquaculture for food in the Pacific remains at a low level, despite decades of introductions and pilot farms. Few have been successful and total regional harvest in 2007 was only around 260 tons, the bulk of it being tilapia fish in Fiji (143 tons) and PNG (67 tons); the governments of both countries are actively encouraging expansion. Some other food aquaculture products, such as shrimp, are grown mainly for the tourist trade. Embryonic coastal clam, fish, and seaweed farming also exist in some countries.

Fish farming for food is sometimes of local importance, such as in PNG, where between 10,000 and 20,000 households are believed to be growing tilapia in the remote highlands and northern coastal provinces where other protein sources are in short supply. However, most of these operations (e.g., those in Fiji, Kiribati, and Solomon Islands) are government subsidized.[29]

Table 9: Aquaculture Production for Local Food, Selected Pacific Countries, 2007

Country	Commodity	Production (tons)	Production per Capita (kg/person/year)
Cook Islands	Tilapia	2	0.13
Fiji	Tilapia	143	0.17
Kiribati	Milkfish	4	0.04
Nauru	Milkfish	8	0.81
Palau	Milkfish	2	0.10
Papua New Guinea	Tilapia, carp, trout	67	0.01
Samoa	Tilapia	10	0.06
Vanuatu	Tilapia	13	0.06

kg = kilogram.
Source: Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Manila: ADB.

29 Gillett, Fisheries in the Economies.

Consumption. Fish consumption in many Pacific countries is currently among the highest in the world (Table 10). The lowest fish consumption rates on a national basis are in the high-island countries—PNG, Solomon Islands, Timor-Leste, and Vanuatu—in which marine fish are not always available (if at all) in inland or highland areas.

Table 10: Fish Consumption in Pacific Countries in the 1990s

Rank	Country	Annual Fish Consumption Per Capita (kilogram)	Rank	Country	Annual Fish Consump-tion per Capita (kilogram)
1	Kiribati	72.0–207.0	8	Fiji	44.0–62.0
2	Tuvalu	85.0–146.0	9	Marshall Islands	38.9–59.0
3	Palau	84.0–135.0	10	Nauru	46.7
4	Micronesia, Federated States of	72.0–114.0	11	Solomon Islands	32.2–32.7
5	Tonga	25.2 – 30.0, 58[a]	12	Vanuatu	15.9–25.7
6	Cook Islands	47.0–71.0	13	Papua New Guinea	18.2–24.9
7	Samoa	46.3–71.0	14	Timor-Leste	5[b]

Consumption rates show the range of averages as determined by various studies in the 1990s. (Gillett 2009).

a Estimate based on subsistence plus locally marketed coastal fish, in Gillett (2009). This differs from estimates in the same book (25.2 to 30.0 kg) but uses more recent data.

b United Nations Development Assistance Framework 2009–2013 Timor-Leste. www.tl.undp.org/RBAA_file/UNDAF%20 2009–2013.pdf?bcsi_scan_9688B637A46568DB=0&bcsi_scan_filename=UNDAF%202009-2013.pdf

Source: Gillett, R. 2009. Fisheries in the Economies of the Pacific Island Countries and Territories. *Pacific Studies Series*. Table 5, with modification to Tonga. Manila: ADB.

A figure of 35 kg/person/year represents about half the average protein requirement for Pacific islanders and is a useful benchmark for both food security and nutrition. The rationale, as set out in a timely recent paper,[30] is that while the World Health Organization recommends that the daily protein intake for good nutrition—about 0.7 grams of protein per kg body weight per day—should be derived from a variety of sources to prevent micronutrient deficiencies, fish will continue to be the main protein source for the Pacific. This is in view of the strong tradition of eating fresh fish, the nutritional and health benefits of fish, and the limited range of protein from available crops and animals in the region. In Asia and elsewhere, the level of fish consumption is more likely to be driven by market forces; in the Pacific, much fish comes from subsistence fishing that will continue in the future. Domestic consumption is almost all from coastal catch, of which more than two-thirds is from subsistence fishing. Subsistence catch is dominant in all the countries except Tonga, where the coastal commercial catch—the fish caught in inshore waters and sold—is greater.

Fish consumption in rural and/or coastal communities is generally higher than that in urban areas, and the great majority of fish is eaten fresh. In most of the Pacific countries, 60%–90% of fish consumed in rural and/or coastal areas is for subsistence, and fresh fish makes up 65%–99% of the total. In urban areas, the proportion of fresh fish consumed ranges from 38% to 97% and is generally more than 75%. However, average fish consumption across the region is expected to decline, largely because of population growth and limitations on expanding coastal fisheries. Given the Pacific islanders' high dependence on fish for food, this would create nutrition deficiency in some countries.

Nutrition[31]

Hunger and food supply do not seem to have been an issue in Pacific countries until possibly lately. These countries have generally managed to avoid acute food shortages except at times of major natural calamities. Recent data also show that more than one-third of the region's population lives below the national poverty line, with very low purchasing power (Table 7). Throughout the region, it is generally the case that the value of production for home consumption significantly exceeds the value of production

30 Bell, J.D., et al. 2009. Planning the Use of Fish for Food Security in the Pacific. *Marine Policy*. 33. pp. 64–76.

31 McGregor, A., et al. 2009. Pacific Island Food Security: Situation, Challenges and Opportunities. *Pacific Economic Bulletin*. 24(2). pp. 24–42.

for sale, as illustrated by data from recent household income and expenditure surveys (Table 11). For example, the value of production for home consumption represents about 55% of household income in Tuvalu, whereas sale of own produce represents only 3% of household income. Solomon Islands has significantly higher contribution to household income from production consumed at home (37%) than from sales (6%), as does Samoa (26% and 3%). Kiribati and Tonga show more equal contributions: in Kiribati, 21% of production is consumed and 11% of household income is from sales; in Tonga, 17% is consumed and 14% is sold. The minimum contribution of home production to household income varied from 7% in Samoa and Solomon Islands to 30% in Tuvalu, while the maximum shares varied from 36% in Tonga and Federated States of Micronesia (FSM) to 71% in Solomon Islands.

Table 11: Proportion to Total Household Income of Value of Production Food Use versus Sales in Selected Pacific Countries

Items	Samoa[a]	Kiribati[b]	Tonga[c]	Solomon Islands[d]	FSM[e]	Palau[f]	Tuvalu[g]
Subsistence production as percentage of household income	26	21	17	37	23	3	55
Sales of own produce as percentage of household income	3	11	14	6	…	…	2
Contribution to GDP (%)	11	48	7	…	22	…	13
Regional variation within Pacific countries from data disaggregated by region/province							
Minimum contribution of home production (subsistence and sales) to income within the Pacific country	7	19	14	7	15	…	30
Maximum contribution of home production	42	50	36	71	36	…	65

… = no data available, FSM = Federated States of Micronesia, GDP = gross domestic product.

a Government of Samoa. 2002. *Household Income and Expenditure Survey*. Tabulation report. Samoa Bureau of Statistics, Ministry of Finance, Apia.

b Government of Kiribati. 2006. *Household Income and Expenditure Survey*. Final report. Kiribati National Statistics Office, Ministry of Finance, Bairiki, Tarawa.

c Government of Tonga. 2001. *Household Income and Expenditure Survey Report 2000–2001*. Department of Statistics, Nuku'alofa.

d Government of Solomon Islands. 2006. *Household Income and Expenditure Survey Report 2005–2006*. National and provincial report. Honiara: National Statistics Office.

e Government of the Federated States of Micronesia. 2005. *Household Income and Expenditure Survey*. Analysis report. Office of Statistics, Budget and Economic Management, Overseas Development Assistance and Compact Management, Palikir Station, Pohnpei State.

f Government of Palau. 2006. *Household Income and Expenditure Survey Report*. Bureau of Budget and Planning, Office of Planning and Statistics, Koror.

g Government of Tuvalu. 2006. *Household Income and Expenditure Survey 2004–2005*. Final report. Ministry of Finance, Economic Planning and Industries, Vaiaku, Funafuti.

Sources: McGregor, A., et al. 2009. Pacific Island Food Security: Situation, Challenges and Opportunities. *Pacific Economic Bulletin*. Table 1. 24(2): 24–42.

As reported by countries with available information, food calorie intake has increased in the region over time (Table 7). As a result, the proportion of the population receiving less than the minimum dietary requirements has declined, albeit very slightly, in all countries except Timor-Leste. The 2003–2005 estimates show that less than 10% of the population in Fiji, Kiribati, Samoa, Solomon Islands, and Vanuatu remains below the minimum level of dietary energy requirements. The calorie deficiency in food intake of the undernourished segment of the population has also been reduced except in Samoa and Timor-Leste. Traditional small farming systems have provided people, especially in rural areas, with ready access to their staple diets of root crops, leaves, coconuts, and fruits from their own production, and fish from their own catch, likewise providing them with foods of very high nutritional value.

While subsistence food production continues to provide a significant proportion of food energy (calories) and protein across the region, particularly in Melanesia, and sales of such produce contribute significantly to household income in some countries, it is difficult to generalize at the regional, subregional, or even national levels because conditions vary greatly between islands and between rural and urban settings. For instance, in the Solomon Islands, subsistence production and sales of food contribute only 7% to household income in Honiara, but 71% in Isabel Province. The same can be observed in Kiribati, the FSM, Samoa, Tonga, and Tuvalu.

Factors Influencing Food Security

Growing Food Imports

Recent developments in the Pacific region indicate a gradual deceleration of local food production (including fish production) and erosion of subsistence farming, amid increasing population and rate of urbanization. The region has to rely, therefore, on food imports to fill the gaps in local demand. In Samoa, for example, five of the eight common energy sources and three of the eight common protein sources are imported, although PNG's energy and protein supply remains mostly locally produced (Table 12).

Dependence on imported foods to contribute to food security in the Pacific is growing and varies widely across the region and among islands within countries. For example, national dependency on food imports (based on food imports as a percentage of total food expenditure) ranges from 36% in Kiribati to more than 80% in Palau (Table 13), but with significant differences between urban centers and rural areas. In the FSM, food import dependency averaged 39% nationally in 2005; it was more than 50% in Pohnpei and Kosrae and less than 20% in Yap.[32]

Table 12: Supply of Energy and Protein Foods, Selected Pacific Countries

Rank	Energy Foods	Contribution to Energy Supply (%)	Import Dependency Ratio (%)	Rank	Protein Foods	Contribution to Protein Supply (%)	Import Dependency Ratio (%)
	Samoa[a]				**Samoa**[a]		
1	Wheat flour/ products	12.6	100	1	Canned fish	21.0	100
2	Coconuts	11.7	0	2	Wheat flour/ products	12.6	100
3	Roots and tubers	9.2	0	3	Chicken	9.6	91
4	Rice	7.4	100	4	Pig meat/pork	9.2	5
5	Pig meat/pork	8.5	5	5	Mutton/lamb	8.8	100
6	Sugar	8.0	100	6	Roots and tubers	6.9	0
7	Canned fish	5.0	100	7	Beef and beef products	6.3	45
8	Mutton/lamb	4.9	100	8	Pelagic fish (fresh and frozen)	2.8	…

	Country	Import Dependency of Food Energy Supply (%) (year)[b]		Country	Import Dependency of Food Protein Supply (%) (year)[b]
	Fiji	58 (1985–2004 average)		Fiji	60 (1985–2004 average)
	Micronesia, Federated States of	73 (2008, Pohnpei)		Micronesia, Federated States of	64 (2008, Pohnpei)
	Papua New Guinea[c]	17 (2006)		Papua New Guinea[c]	24 (2006)
	Solomon Islands	21 (2004)		Solomon Islands	…
	Vanuatu	21 (1997)		Vanuatu	…

… = no available data.

Sources: a UN Food and Agriculture Organization Food. 2002. Balance Sheet, Samoa 2002; b McGregor, A., et al. 2009. Pacific Island Food Security: Situation, Challenges and Opportunities. *Pacific Economic Bulletin*. 24(2). pp. 24–42. c Bourke, R.M. and T. Harwood (eds). 2009. *Food and Agriculture in Papua New Guinea*. The Australian National University, Canberra National University, Canberra, as cited in McGregor, A., et al. 2009.

Food Import Capability.[33] A key factor in the determination of food security is the ability of countries (and individual households) to pay for the food they import. Factors that influence this include export earnings (including from tourism), levels of debt service payments, and remittances. FAO has developed the Food Import Capability Index (FICI), the proportion of the total value of food imports in the total value of food exports, as an indicator of a country's relative ability to import food

32 McGregor et al. Pacific Island Food Security.
33 McGregor et al. Pacific Island Food Security.

and of its vulnerability to food insecurity. Countries with an FICI of more than 0.5 are considered vulnerable to food insecurity, while those with an FICI over 1.0 are highly vulnerable. Based on available 1990–2001 data, Fiji, PNG, and Solomon Islands have low FICIs and are among the most food secure Pacific countries (Table 13). In contrast, the food security of Samoa and Tuvalu appear to be the most vulnerable, with average FICIs of 2.59 and 5.48, respectively.

When services, remittances, and servicing of foreign debts were included in the FICI calculation (now called the FICI "plus"), a different pattern for some countries emerged. The food security status of Samoa moved from being "extremely vulnerable" to "moderately vulnerable," and that of Vanuatu moved from being "moderately vulnerable" to "low" (Table 13). In assessments conducted over 1986–2007, clear trends were shown in only two countries (Figure 3): PNG showed a steady improvement in food security (already strong in the 1980s), and Fiji posted a gradual deterioration in food security (due to falling sugar export earnings and increasing debt servicing).

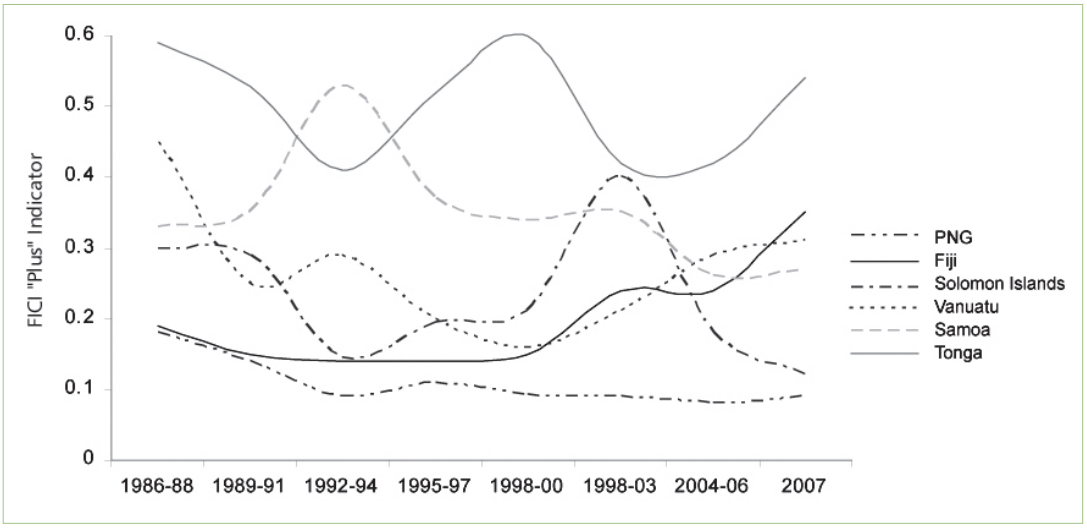
The contribution of earnings from services, such as tourism and remittances, illustrates the vulnerability of the Pacific countries' food security to external economic shocks, such as a global financial crisis, which is likely to reduce these earnings. Food security of countries with low export earnings, like Kiribati and Tuvalu, are likely to be more vulnerable than those with significant foreign exchange incomes from product exports. As such, increased dependence on imports to improve the food security situation can be worrisome for small countries where accessing income opportunities can also be a challenge.

Table 13: Food Import Dependency and Food Security Vulnerability in Selected Pacific Countries

Country	Proportion of Imported Food in Total Food Expenditure (%)[a] (year)	FAO Food Import Capability Index (FICI)[b] 1990–2001 Average	Vulnerability of Food Security based on FAO FICI (>0.5 = vulnerable; >1.0 = highly vulnerable)	FAO Food Import Capability Index (FICI) "Plus"[c] 1990–2001 Average
Cook Islands	…	1.84	Extremely vulnerable	…
Fiji	…	0.17	Low	0.15
Kiribati	36 (2006)	1.56	Extremely vulnerable	…
Micronesia, Federated States of	39 (2005)	…	…	…
Palau	81–84 (2006)	…	…	…
Papua New Guinea	…	0.12	Low	0.14
Samoa	56 (2002)	2.59	Extremely vulnerable	0.46
Solomon Islands	35–44 (2006)	0.15	Low	0.12
Tonga	45 (2001)	1.10	Highly vulnerable	…
Tuvalu	…	5.48	Extremely vulnerable	…
Vanuatu	…	0.46	Moderately vulnerable	0.18

… = no data available, FAO = Food and Agriculture Organization.
a From country household income and expenditure surveys, various years.
b FICI = proportion of total value of food imports in the total value of food exports.
c FICI "plus" = proportion of total value of food imports in the total value of food exports, including services, remittances, and servicing of foreign debts.
Source: McGregor, A., et al. 2009. Pacific Island Food Security: Situation, Challenges and Opportunities. *Pacific Economic Bulletin*. 24(2). pp. 24–42.

Figure 3: Food Import Capability Index "Plus" Indicators for Selected Pacific Countries, 1986–2007



PNG = Papua New Guinea.
Note: The Food Import Capability Index (FICI) "plus" is a refinement of FICI by including services and remittances.
Source: McGregor, A., et al. 2009. Pacific Island Food Security: Situation, Challenges and Opportunities. *Pacific Economic Bulletin*. Figure 7. 24(2). pp. 24–42. Reproduced with permission from the Pacific Economic Bulletin.

Nutrition Impacts of Food Imports. Table 12 in the earlier section showed that food imports are rapidly replacing traditional diets. Imported white rice has now become a staple around the Pacific, substituting, along with other cereals, for the traditional taro and other root crops in the diet. However, white rice is far inferior in most nutritional aspects to root crops. For example, taro corms, leaves, and stalks are richer in minerals than white rice; they also contain vitamins A (carotenoids) and C, neither of which is found in white rice.[34]

The substitution of white rice for taro is but one indication of the Pacific's nutrition transition problem—the shift from relatively monotonous diets of indigenous grains or starchy roots, with local legumes, vegetables, and limited animal protein (mostly fish in the Pacific) to a more varied diet with more processed foods, more foods of animal origin, more added sugar and fat, and often more alcohol.[35] By 2050, the dietary patterns in the region are expected to significantly change toward more animal protein content because of urbanization and the expected income growth. This will require the region to utilize more wheat and corn as feedstock for the expected expansion in livestock production, resulting in higher import growth of these commodities.[36] Table 14 gives examples of the general shift in the Pacific diet from traditional to more modern food items, many of them imported and often of low nutritional value, because governments cannot generally afford to import better quality food. As one recent observer stated, "[t]otal food availability in the Pacific islands is becoming increasingly a function of the ability to pay for food imports."[37]

34 Brown or unpolished rice, however, is quite nutritious, with four times as much fiber as white rice. Some vitamins and much mineral content are also lost in the rice polishing process (removal of the germ and bran layers).
35 Popkin, B., S. Horton, and S. Kim. 2001. The Nutrition Transition and Prevention of Diet-Related Chronic Diseases in Asia and the Pacific. *ADB Nutrition and Development Series* No. 6. Reprinted from *Food and Nutrition Bulletin*. 2001. 22(4). Special supplement.
36 FAO. 2010. *T*he Outlook for Supply and Demand in the Asia–Pacific Region and the Need to Increase Agricultural Production. Paper presented at the Food Security Ministerial Meeting in Niigata, Japan, 16–17 October 2010.
37 Barnett, J. 2007. Food Security and Climate Change in the South Pacific. *Pacific Ecologist*. Winter 2007. pp. 32–36.

Table 14: Examples of Dietary Changes in Pacific Countries

Traditional Diet	Modern Diet
Locally produced	Mostly imported
Fresh fish	Canned fish; corned beef
Root crops, breadfruit, banana	White rice, bread, instant noodles
Water, coconut juice	Sweetened soft drinks
Raw, grilled, boiled, earth oven	Fried

Source: FAO Sub-regional Office of the Pacific Region.

The general inability of Pacific countries to avail themselves of high-priced and better-quality food products has also contributed to the deteriorating nutrition conditions in many of them. Increased incidence of noncommunicable and lifestyle diseases like obesity, heart disease, and diabetes, as well as deficiencies in vitamins and minerals, have been reported in the region (Box 1).

Such imported foods have advantages over local produce in being cheaper and more convenient to buy, store, and prepare. The resulting dependence on these foods is, however, a consequence of urbanization, which tends to convert agricultural land near cities and towns to cash crops, making traditional foods more distant and inconvenient. Compounding the situation is the slow rise of the "cash economy" and the weakening of the local support system that traditionally provided the safety net against hardships, food inaccessibility, and, hence, hunger. Now, imported food increasingly competes with locally produced food in Pacific diets to the extent that, in Fiji, as in other islands where traditional agriculture is still extant, "[n]o household is any longer self-sufficient in its food supply. Most rural households continue to produce their traditional foodstuffs, however, no household depends entirely on their own produce."[38]

Box 1: Food Imports and Nutrition in the Pacific

The brief paragraph below from a July 2011 bulletin of the World Health Organization summarizes key findings of a recent health study conducted in the Pacific:

"In at least 10 Pacific island countries, more than 50% (and in some, up to 90%) of the population is overweight. More seriously, obesity prevalence ranges from more than 30% in Fiji to a staggering 80% among women in American Samoa …. Diabetes prevalence among adults in the Pacific region is among the highest in the world; 47% in American Samoa … and it ranges from 14% to 44% elsewhere in the region. Micronutrient deficiencies are also common in the region. In 15 of 16 countries surveyed, more than one-fifth of children and pregnant women were anaemic. Vitamin A deficiency is also a significant public health risk in Kiribati, the Marshall Islands, FSM, and PNG. Non-communicable diseases, notably cardiovascular disease, diabetes and hypertension, account for three-quarters of all deaths across the Pacific archipelago and 40–60% of total health care expenditure."

Source: World Health Organization. 2010. Pacific islanders pay heavy price for abandoning traditional diet. Bulletin of the World Health Organization. www.who.int/bulletin/volumes/88/7/10-010710/en/index.html

An important consequence of dependence on imported foods is that more and more people, especially in urban areas, are relying on commercial markets for their foods. Thus, "food market and cash income risks, rather than merely production risks, become major determinants of household food security in the South Pacific island countries."[39] In addition, the economies and food security situation of the country and/or the region becomes inherently open to fluctuations in international market supply and demand and to the volatility of global prices, potentially making them more vulnerable when problems arise in the world food market.

38 Foraete, H.M. 2001. Food Security Strategies for the Republic of Fiji. In *Food Security in Southwest Pacific Island Countries*. Proceedings of a workshop held in Sydney, Australia, 12–13 December 2000. Bogor: CGRPT Centre. www.uncapsa.org/publication/cg40.pdf

39 Simatupang and Fleming, *Food Security in Southwest Pacific Island Countries*.

Global Food and Fuel Prices

The FAO international food price index showed an increase by 68% between February 2009 and April 2011, rising above its 2008 peak in January 2011.[40] The resurgent rise in international food prices has sparked concerns about rising inflation, increasing poverty, and longer-term "food crisis." It can, however, be explained by changes in market fundamentals such as weather-induced supply shortfalls; declining productivity; strong general food demand growth in emerging market economies; higher demand for meat and biofuels; tight stock levels; higher fuel, transport, and agriculture feedstock prices; and loose monetary policies in some countries.

The magnitude of the effects of the rising international food prices in any Pacific country mainly depends on the level of the country's reliance on imported food, and is compounded by already high transport costs and rising international fuel prices. Rising international food prices can lead to higher inflation, increased poverty, and public health ramifications. However, a country's vulnerability to increasing international food prices will also depend on its ability to pay for imported food because, at the same time, higher international food prices could potentially benefit food exporters from Pacific countries.

Similarly, recent international oil prices have increased chiefly because of strong demand, particularly from newly emerging economies engaged in rapid industrialization; underinvestment in exploration, production, and refining; Organization of the Petroleum Exporting Countries (OPEC) supply policies; higher exploration and production costs; and uncertainty fueled by tensions in the Middle East. The trend represents a major supply-side shock to Pacific countries, resulting in increasing transport, electricity, and production costs and a higher cost of living. The Pacific countries most vulnerable to rising international oil prices are those which rely on oil for energy generation, have a low export base, and no domestic oil production.

Considering these two important factors, the Australian Information Note for the July 2011 Forum Economic Ministers Meeting states that the countries highly vulnerable to both food and fuel price increases are Kiribati, the Marshall Islands, and Nauru. Exchange rate arrangements, local exchange rate developments, and the currency used to pay for their food and fuel imports will determine the impacts of increasing international prices on local economies in the Pacific.

The rise in food and fuel prices can be beneficial to Pacific producers if such price increases are reflected in the local produce markets and consumers switch to this produce. However, poor marketing infrastructure, including transport links, limits producers' ability to take full advantage of these higher prices. The rapid rise in fuel prices also raises the prices of farm inputs (e.g., fertilizer) and limits the opportunities for increased agricultural production and incomes.[41]

For the major part of the population, however, high food and fuel prices translate to greater food insecurity and impoverishment, especially for the poor, who spend 70% of their income on food. Higher prices also result in lower real wages or massive layoffs as industries strive to lower production costs and stay viable. Households in the atoll countries and low-income households in the urban areas are bound to suffer the impact. Many will be forced to respond by reducing food consumption and/or cutting expenditures in other basic needs such as education and health. Others may switch to cheap and low-quality food (imports), which can lead to poor diets and health problems. Unless replaced by traditional foods, these trends would adversely affect their well-being and opportunities.

Disasters and Emergencies

A disaster is a sudden, calamitous event that seriously disrupts the functioning of community or society, causing widespread human, material, economic, or environmental losses that exceed the community's or society's ability to cope using its own resources. Disasters result from a combination of hazards, vulnerability, and inability to reduce the potential negative consequences of risk, and can be caused by natural events (e.g., earthquakes, tsunamis, cyclones, epidemics); by technological or industrial

40 Commonwealth of Australia. The Second International Food and Fuel Price Shock and Forum Island Economies: An Information Note. Prepared for the Forum Economic Ministers' Meeting held in Apia, Samoa, July 2011.

41 McGregor, A. 2005. *Pacific 2020 Background Paper: Agriculture*. Canberra: Australian Agency for International Development.

accidents (e.g., oil spills, chemical mishaps); or by conflicts. An emergency occurs after a disaster when unforeseen circumstances require immediate action and local capacity is insufficient to address and manage traumatic events.[42]

Large-scale disasters and emergency situations have significant humanitarian, social, security, political, and economic implications. They leave large numbers of people with no or limited access to basic needs (e.g., food, medicine, clothing, shelter); safety is disrupted; and large portions of the population may lose access to economic resources and opportunities.

The general vulnerability of Pacific countries to extreme climate events and unfavorable global economic trends can adversely affect their capacity to produce and/or import food. The situation can eventually require emergency food aid from the international community. Some countries in the Pacific region have received emergency food aid in the past, especially after devastation from tropical cyclones and storm waves. Australia, for example, provides approximately 150,000 tons of food aid every year—about $100 million—to people in crisis in other countries.

Other Factors

Traditional and subsistence agriculture, which have been the Pacific countries' life support, were established in customary lands and developed around a combination of tree crops (e.g., coconut, breadfruit, and pandanus) and the cultivation of taro or other root crops. The crop combinations vary widely both across and within the countries depending on the topography, amount and frequency of rainfall, and market potential. The systems are increasingly diversified, with the cultivation of fruit trees like papaya and other alternate crops like sweet potatoes, limes, and vegetables. Virtually all inputs are supplied within the system, so there is no requirement for formal land title, working capital, or credit, all of which are considered as major constraints to commercial agricultural development. Even agroforestry systems based on established traditional technologies were proven to be effective risk management strategies. Food crops were not sold but shared or exchanged.

The geographic and physical topography of Pacific countries poses barriers to improving the region's agricultural performance. Land and water resources are limited and very fragile, hence prone to rapid degradation. Soils are generally nutrient-poor (i.e., lacking in nitrogen, phosphorous, potassium, and calcium), sandy, porous, and high in salinity and alkaline. The soil's poor water retaining properties limit the range of crops that can be cultivated in the 70% rainfed cropped area. The topographical features also present infrastructure (e.g., storage, transport, and communications facilities) challenges, affecting the development of input and output markets.

The traditional agricultural system has declined substantially in recent times and no longer exists in some islands.[43] In many atolls, for example, pit taro cultivation has been greatly reduced, sometimes by seawater infiltration into the freshwater lens due to overuse by growing populations, and in some cases sea-level rise. One technical factor is the erosion of genetic diversity, threatening the nutritional value of staple crops and enhancing their susceptibility to pest and disease outbreaks. An economic factor is the gradual depopulation of many rural areas and outer islands, tending to diminish the importance of rural agricultural production and place more emphasis on a cash economy. The production slowdown in agriculture necessitated people from the rural areas to seek other sources of income to meet their cash needs, and to depend more on processed (imported) foods that strongly compete with the traditional foods. Particularly where there has been introduction of monoculture agriculture as cash crops, such as copra, coffee, and sugarcane, the cash economy has become dominant and led to increasing demand for imported foods. Moreover, "attempted shifts toward modern agricultural economies and more affluent industrial societies have failed to deliver the resilient agricultural and food systems developed countries enjoy. If anything, they have weakened traditional agricultural systems."[44]

42 ADB. 2011c. Disaster and Emergency Assistance Policy. Manila. www.adb.org/Documents/Policies/Disaster_Emergency/de002.asp

43 FAO. 2008. *Climate Change and Food Security in the Pacific Islands*. Rome.

44 Barnett, Food Security and Climate Change.

Similarly, increased urbanization and globalization is eroding the traditional support networks that help to safeguard food security. The large quantities of imported foods that were incorporated in the Pacific diets in the last decades have contributed to the slow demise of the traditional agricultural system and support network systems. Exchanging of local atoll food for imported food between relatives living in the outer islands and those living in urban centers also became common.

Meanwhile, technological constraints to agricultural production include (i) the lack, or absence, of new or improved agricultural production technologies; and (ii) declining investments in research to develop these production technologies and practices. There are also institutional and policy constraints to the improvement and sustainability of agricultural production in the Pacific: (i) insecurity of tenure, which hinders incentives to invest and modernize; (ii) poor access to support services, including credit and insurance; (iii) weak or limited individual, institutional, and economic capacities; and (iv) poor regulatory and governance environments that often lack priority and focus.

In addition, private sector investment has been difficult to attract because of (i) extensive state involvement in economic affairs, (ii) high cost of operating environment because of costly and unreliable infrastructure and weak regulatory regimes, (iii) insecure land tenure and lack of well-functioning, secured transaction frameworks resulting in financial markets, (iv) lack of supporting laws and their enforcement and discretionary foreign investment policies, (v) looming macroeconomic instability resulting from fiscal imbalances and excessive debt, (vi) poor governance, and (vii) political instability.

Exacerbating the effect of all these constraints on food production, and hence food security, is the expected devastating effect of climate change and other natural disturbances. These are presented and discussed in more detail in Chapter 3.

Climate Change Threats and Impacts on Food Security

"Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems." (IPCC Fourth Assessment Report, 2007)

Climate change is anticipated to be the most significant threat to enhancing global food supply, and hence to further improvements of food security, especially in developing countries. Climate change can prevent the Pacific countries from attaining their Millennium Development Goals and poses threats to peace, prosperity, and security.

This chapter presents a general description of the current experiences with and projected changes in the climate conditions of the Pacific region. It discusses the direct and indirect effects and their immediate and long-term consequences, particularly on food security, in the countries. The areas relating to climate change adaptation and/or food security responses from the international community of development partners will be discussed in Chapter 4.

Evidence of Climate Change

Until recently, scientific research in the Pacific has been sparsely scattered, making it difficult to establish that climate change is indeed taking place in the region. However, many residents attest that their observations and experiences with the weather today are very much different from those of one or more decades ago.

Compared with earlier historical records during the 20th century, the southern Pacific islands have experienced a 15% drier condition and an atmospheric temperature that is 0.8°C warmer. The Central Equatorial Pacific, on the other hand, has been noted as experiencing about 30% more intense rain and a 0.6°C warmer climate condition. In both areas, sea surface temperatures have increased by about 0.4°C. Based on data from 11 tide gauges installed in 11 Pacific countries, relative sea levels in the South Pacific have been rising by as much as 2.5 centimeters per year since 1994. This is more than 10 times the global rate of sea-level rise this century. All these conditions are believed to be linked to an increased frequency of El Niño episodes since the 1970s without alternating La Niña events.[45]

The South Pacific, likewise, is reported to be experiencing significant increases in cyclone occurrences, especially during El Niño events. For example, compared with the per-season average of 9–10 cyclones that visit, the South Pacific had 16 cyclone events in 1992/93 and 17 cyclone events in 1997/98. In October 2007, rainfall was extremely high in many areas under the active South Pacific Convergence Zone, reaching more than 200% of the normal rainfall in parts of Fiji, central French Polynesia, and Vanuatu. Also in October 2007, mean air temperatures were 1.5°C or more above normal in parts of Tonga and the Southern Cook Islands, and 1.0°C or more above normal in New Caledonia and parts of Fiji. It was the warmest October ever recorded in Nadi, Fiji at that time.[46]

The above occurrences in the Pacific are consistent with what are transpiring across the globe. However, the Pacific's unique geophysical features and social, economic, and cultural characteristics render the islands particularly vulnerable to the effects of global warming, including more frequent and

45 Hay, J.E., et al. 2003. *Climate Variability and Change and Sea-level Rise in the Pacific Islands Region: A Resource Book for Policy and Decision Makers, Educators and Other Stakeholders*. Apia, Samoa: South Pacific Regional Environment Programme.

46 NIWA, et al. 2007. *The Island Climate Update* No. 86. November. www.niwa.co.nz/our-science/pacific-rim/publications/all/icu/2007-11

intense natural disasters such as the cyclones, floods, and droughts that have been experienced recently. In the 1990s, extreme events were estimated to have cost the Pacific region more than $1 billion, of which $440 million was due to cyclones Ofa and Val, which hit Samoa in 1990 and 1991. The losses were greater than Samoa's average annual GDP in recent years. It also included damages due to Cyclone Heta in Niue worth $27 million (NZ$37.7 million), or approximately 25% of its GDP.[47] Typhoon Heta and Tropical Cyclone Ofa turned Niue from a food-exporting country into one dependent on imports for the next 2 years.[48] Moreover, the cleanup and reconstruction process following Heta cost the region an estimated $150 million. Similarly, the Cook Islands experienced five cyclones within a 5-week period in early 2005, four of which were classified as Category 5. In the decades prior, the country could expect a storm of this magnitude approximately every 20 years.

Fiji's experience with the 1997/98 El Niño Southern Oscillation (ENSO) event resulted in losses in the sugarcane industry of around $75 million (about F$104 million) and livestock death worth around $10 million (F$15 million).[49] In February 2008, Cyclone Gene caused Fiji around $32 million (more than F$45 million) in damages to agriculture (excluding the sugar industry), infrastructure, utilities, and properties. In addition, the government had to provide around $1.2 million (FJ$1.7 million) worth of food rations.[50]

In the fishery subsector, efforts at monitoring and relating the changes in the health of marine ecosystems to climate change are only recent, and some evidence of climate change impacts has been observed. For example, the distribution of skipjack tuna in the Pacific Ocean varies with the alternate phases of El Niño and La Niña cycle in the western and central Pacific. ENSO events largely determine the location of skipjack tuna in these water bodies—they move further east during El Niño years and then follow the warm pool west during the La Niña episodes.[51]

In the forestry subsector, it also has been difficult to relate the loss of forest resources to climate change, mainly because of outdated forest inventories and a paucity of other data. Some observed changes that could be attributed to climate change are the variation in the flowering and fruiting patterns of certain forestry crops and the increased incidence of pest and diseases in species such as sandalwood, whitewood (caterpillar attack), and mahogany (shoot borer). Invasive species are also more widespread and seed collection from major species has been particularly low compared with past years.[52]

Similarly, mangrove areas are believed to be declining in the Pacific, even in certain isolated areas where population densities remain low. Pollution from land-based activities that flows to mangrove areas during strong storms is perceived as the most common threat, although land clearing is also a threat. Sea-level rise also affects the growth and productivity of these areas.

In summary, many Pacific islands are already experiencing disruptive changes consistent with the expected effects of climate change—more erosion from rains and storms; more frequent storm surges, floods, and droughts; saltwater intrusion on land due to storms; coral bleaching from increasing seawater temperatures; more widespread and frequent vector-borne diseases due to increasing areas of suitable habitat for the vectors with warmer temperatures; and periods of exceptionally high sea levels.[53]

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47 McKenzie, E. A. Kaloumaira, and B. Chand. 2005. *The Economic Impacts of Natural Disasters in the Pacific*. Technical report. Suva: University of the South Pacific and the South Pacific Applied Geoscience Commission.

48 Adger, W.N., et al. 2007. Assessment of adaptation practices, options, constraints and capacity. In Parry, M.P., et al, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press. 717–743.

49 McKenzie and Chand, *Economic Impacts of Natural Disasters*.

50 Relief Web. 2008. Press release on Tropical Cyclone Gene rehabilitation. http://reliefweb.int/node/257323

51 Lehodey, P., F. Chai, and J. Hampton. 2003. Modeling Climate-related Variability of Tuna Populations from a Coupled Ocean Biogeochemical–Population Dynamics Model. *Fisheries and Oceanography*. Vol.12. pp. 483–494; Lehodey, P., et al. 1997. El Nino Southern Oscillation and Tuna in the Western Pacific. *Nature*. Vol. 389. pp. 715–718; and Loukos, H., et al. 2003. Potential Changes in Skipjack Tuna (*Katsuwonus pelamis*) Habitat from Global Warming Scenario: Modeling Approach and Preliminary Results. *Fisheries Oceanography*. Vol. 12 (4–5). pp 474–482.

52 FAO, *Climate Change and Food Security*.

53 ADB. 2010. Responding to Climate Change in the Pacific: Moving from Strategy to Action. *Pacific Studies Series*. Manila.

Elements of Future Threats from Climate Change

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has identified small islands as being among the countries most vulnerable to the adverse impacts of climate change.[54] Although the Pacific region accounts for less than 0.1% of global greenhouse gas emissions, the Pacific countries are expected to suffer disproportionately from the impacts of climate change. Climate scientists have made the following projections regarding the changes in climate in the Pacific:[55]

- sea-level rise of 0.19–0.58 meters by 2100, resulting in accelerated coastal erosion and saline intrusion into freshwater sources;
- surface air temperature increases of 1.00–4.17°C in the northern Pacific and 0.99–3.11°C in the southern Pacific by 2070, leading to increases in sea surface temperature by 1.0–3.0°C;
- ocean acidification with increasing concentration of dissolved carbon dioxide, causing pH to drop by an estimated 0.3–0.4 units by 2100 and adversely impacting growth rates of corals and other calcium carbonate–forming marine organisms;
- rainfall increases or decreases from –2.75% to +25.8% in the northern Pacific and –14.0% to +14.6% in the southern Pacific, causing worse floods or droughts; and
- more intense tropical cyclones, with increased peak wind speeds and higher mean and peak rainfall.

Table 15 summarizes the projected changes in the Pacific climate and their key consequences on various sectors, particularly those relating to food security. The climate change projections and their likely impacts on some countries in the Pacific are detailed in Appendixes 3a and 3b. These details show that the projected climate change threats and expected consequences are the same for all the countries, but their intensity and magnitude definitely vary.

Climate Change and Food Security

Climate change–induced extreme weather events and sea-level rise have direct effects on the biophysical and socioeconomic systems influencing food production, and indirect impacts and consequences on food security per se. The projected impacts of warmer atmospheric and open water temperatures, erratic rainfall intensity and distribution, more frequent and more intense tropical cyclones, sea-level rise, etc., on land, soil and water resources, agricultural production systems (including those of livestock and fisheries), infrastructure, and social (community) systems will in turn influence the consequences of climate change on food security. A decline in agricultural production and lack, or absence, of significant other development initiatives and opportunities may jeopardize a country's ability to feed itself, including its capability to import food. These relationships are briefly described in the following paragraphs.

Impacts on Crops

Increased temperatures, more frequent and prolonged dry conditions, increased variability of rainfall, salt water intrusion, droughts, soil erosion, and cyclones have increasingly put pressure on crop production in both commercial and subsistence agriculture. The projected temperature increases will most likely reach the maximum heat tolerance thresholds of crops and induce heat stress, wilting, and crop failure, especially in traditional crops like taro, yam, and arrowroot. Dry conditions during El Niño years are most devastating to farming activities in the Pacific, most of which are located in rainfed areas. Coastal and low-lying farms will suffer from seawater inundation and intrusion of saltwater into underground freshwater lenses.

54 IPPC. 2007. *Fourth Assessment Report of Working Group II*. 2007. www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

55 ADB. 2009c. Mainstreaming Climate Change in ADB Operations: Climate Change Implementation Plan for the Pacific (2009–2015). Appendix 1. *Pacific Studies Series*. Manila.

Table 15: Projected Changes in the Pacific Climate and Oceans Relative to 1980–1999 Levels and Their Key Consequences

Climate Feature/ Threat	Projected Climate Changes	Key Consequence(s)
Surface atmospheric temperature (drought and declining rainfall)	1.00–4.17°C in the northern Pacific and 0.99–3.99°C in the southern Pacific by 2070	• Plant and animal stress—heat and pest and disease incidence: slow growth and low yields • Water shortages for agriculture—drying of streams and ponds • Slower recharge of water lenses • Changes in soil quality • Effects on health, production, and reproductive capacity of animals • Slow growth of corals; coral bleaching • Decreased fish catches • Low productivity of farms • Increased risk of fires
Sea-level rise	8–51 centimeters, depending on the extent of greenhouse gas emissions	• Saltwater intrusion and flooding of low-lying farms and settlement areas • Erosion of soil and shorelines/coastal areas • Inundation of habitats for coconut crabs and other shoreline species • Slow reef and coral growth; coral die-back affecting fishery production • Inundation of coastal springs and underground freshwater sources
Acidification of ocean from carbon dioxide absorption	pH level is expected to drop by 0.3–0.4. Aragonite saturation level in the ocean is expected to be reduced from >4.0 to 3.0–3.5	• Slowdown of coral growth rates, possible loss of reef-forming corals • Coastal waters become corrosive to the shells of some bottom dwellers
Rainfall (precipitation) increase or decrease	From –2.7% to +25.8% in the northern Pacific, and –14% to +14.6% in the southern Pacific	• Potential alleviation of water shortages, especially in small islands • Erosion of soil and soil nutrients • Flooding of agricultural lands • Sedimentation of reefs and lagoons, affecting mangroves, coastal areas, marine species, and fisheries • Runoff that causes pollution of groundwater sources • Growth of less desirable pasture species • Spread of pests and diseases
El Niño Southern Oscillation (ENSO)/ cyclones/ wave surges/ salt spray	ENSO events will continue as a source of interannual climate variability, but may increase in frequency or intensity. The central and eastern equatorial Pacific sea surface temperatures are projected to warm more than the western equatorial Pacific, with a corresponding mean eastward shift of areas of precipitation and tropical cyclone formation. Anomalously wet areas are likely to become even wetter, while unusually dry areas could become even drier.	• Production losses, especially in rainfed areas with more frequent occurrences of El Niño • The divergent occurrence of the two phases of ENSO (i.e., El Niño and La Niña) could bring nutrient-rich waters and improve some fisheries. • Damage to agricultural crops, forest trees, etc., from strong winds, salt spray, wave surges • Loss of traditional food crops as their habitats become damaged by rising sea levels or drought conditions • Destruction of agriculture infrastructure: farm shelters, storage facilities, etc., from strong winds • Spread of wind-borne diseases and pests • Invasion by alien plant and insect species

Source: Summarized from various tables in FAO. 2008. *Climate Change and Food Security in Pacific Island Countries*. Samoa: FAO Sub-Regional Office for the South Pacific.

The prevalence of wetter conditions in the future would benefit water-sensitive crops such as coconut, breadfruit, and cassava. However, intense rainfall, especially during planting seasons, could damage seedlings and reduce growth for seasonal or annual crops. Wetter conditions are also conducive to multiplication and spread of plant pests and diseases and more rapid postharvest deterioration of crops. In areas where waterlogging is a problem, increased rainfall could put equally severe pressure on plant growth that leads to lower production.

Increased rainfall in good years may offset the effect of warmer temperatures, but a warmer and possibly drier climate would lead to more intense drought in El Niño years. In Fiji, for example, by 2050, projected annual costs of increased rainfall damage to important agriculture crops have been estimated at $14 million, and in an extreme drought event, $70 million.[56]

A detailed 2010 World Bank study of climate change in Samoa concluded that its impact on agriculture would be mainly from increased frequency or magnitude of El Niño events, but it is likely to be small relative to existing risks due to weather variability, crop disease, and external market conditions.[57]

Considering the uncertainty of future climates, assessments of climate change on Pacific agriculture can only be broad. Variability of rainfall will increase the demand for drought-resistant crops in drier areas and for water-tolerant crops in wetter areas. Farmers may modify their crop calendars, shift their cropping patterns, diversify the crops grown, or completely shift out of crop agriculture. Overall, the literature implies that the likelihood of agriculture loss outweighs any projected benefits. The risks include crop losses from excess heat and drought on the one hand, and oversaturation of soil and physical damage from increased rainfall on the other.

Impacts on Livestock

Increased temperatures can affect the health, productivity, and reproductive efficiency of animals. Small-scale livestock farmers will be most affected by drought through loss of pasture areas (with compacted and dry soil) and loss of streams and rivers as primary sources of water for animal drinking and bathing. Possible overstocking and overgrazing of remaining pasture lands would in turn result in further degradation of pasture lands and loss of condition of livestock. Wetter conditions, on the other hand, encourage growth and spread of pests and diseases that can endanger animal health.

Increased atmospheric carbon dioxide concentrations and warmer temperatures will be less conducive to the growth of feed and fodder crops,[58] which could reduce the nutritional value of pastures and result in fewer animals that can be supported per unit area of pasture land. This would have a detrimental effect on animal production, particularly beef.

Impacts on Fisheries

Fish stocks will be affected by the destruction of coastal habitats, including mangrove swamps—which provide nursery areas—and coral reefs, as a result of storm surges and/or shoreline erosion. Increasing temperatures promote coral bleaching, leading to coral death and consequent degradation of reef habitats, while expected acidification of the oceans will also affect coral growth and survival. These climate-induced changes will likely reduce the abundance and diversity of reef-forming corals and, thus, reduce reef fish productivity.[59] Coastal fisheries, most of which are essential to subsistence economies, will suffer increasing degradation from overfishing as populations grow, urban areas spread, and fish habitats are lost. Such changes will affect the nutrition and incomes of coastal populations that depend on artisanal fisheries.

Meanwhile, offshore fisheries will see significant medium-term gains. Harvests of skipjack tuna, the dominant offshore species in the tropical Pacific, are expected to increase in the medium term (2035) by nearly 20% relative to catches in 1980–2000. However, catches may suffer a net loss by 2100 depending on the extent of climate change. In an optimistic scenario with a gradual reduction of greenhouse gas emissions, there would still be a net gain of some 12%; in a worse scenario with continually increasing emissions, there would be a net loss of around 7% by 2100.

56 World Bank. 2000. *Cities, Seas, and Storms: Managing Change in Pacific Island Economies*. Washington, DC. web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/EXTARCHIVES/0,,contentMDK:64056215~menuPK:64319213~pagePK:36726~piPK:36092~theSitePK:29506,00.html

57 World Bank. 2010. *Economics of Adaptation to Climate Change*. Samoa. Washington, DC. http://climatechange.worldbank.org/content/samoa-economics-adaptation-climate-change-study

58 National Advisory Committee on Climate Change. 2007. Republic of Vanuatu. National Adaptation Programme for Action. GEF/UNDP/UNFCCC/NACCC, 2007

59 Bell, Planning the Use of Fish.

However, the increased skipjack harvest will likely not be evenly spread across the Pacific. Changes in ocean temperatures and current due to increased ENSO-like conditions will affect migration and change the distribution and abundance of tuna stocks. The western parts of the region—primarily around the FSM, Palau, PNG, and Solomon Islands—will see medium-term gains of about 11%, declining to 0% by 2100 in an optimistic scenario but facing a net loss of more than 20% in the worse scenario. In the eastern part of the region, skipjack tuna catches could increase by nearly 40% in the medium term, increasing marginally by the end of the century in an optimistic scenario, but declining to about 27% net gain in the worse scenario (Table 16).

Table 16: Projected Changes in Catches of Skipjack Tuna, Relative to Those in 1980–2000, in the Tropical Pacific Ocean under Different Climate Change Scenarios (% change)

Region[a]	Optimistic Scenario[b]		Worse Scenario	
	2035	2100	2035	2100
Total Pacific	19	12	19	(7)
Western fishery	11	0	11	(21)
Eastern fishery	37	43	37	27

( ) = negative number.

a Western fishery = 15°N to 20°S and 130°E to 170°E; eastern fishery = 15°N to 15°S and 170°E to 150°W.

b The scenarios represent those used by the *Fourth Intergovernmental Panel on Climate Change Assessment Report*, in which B1 is an optimistic scenario with decreasing greenhouse gas emissions, and A2 is a worse scenario with steadily increasing emissions.

Source: Lehodey, P. et al. Vulnerability of Oceanic Fisheries in the Tropical Pacific to Climate Change. In J.D. Bell, J.E. Johnson, and A.J. Hobday, eds. (in press). *Vulnerability of Fisheries and Aquaculture in the Tropical Pacific to Climate Change*. Noumea: Secretariat of the Pacific Community.

A Pacific-wide increase in skipjack tuna alone of 12% by 2035 would be equivalent to around 10 kg/person/year across the region, and perhaps more than double that if the existing "heavy" fish consuming countries and PNG are excluded (Table 10 in Chapter 2). Against this bright prospect, tuna distribution from centralized points would face significant logistic problems and costs, given the vast distances between islands within and among countries. Further, diverting tuna from distant-water fleets would be unlikely due to strong demand (and hence high prices) for tuna in western markets. The Pacific countries have consistently voiced their desire to increase their economic benefits from selling rights to tuna fishing.

Aquaculture is a developing industry in the Pacific region and plays an important role in diversifying trade, increasing capacity for fishery production, and contributing to rural development. Marine aquaculture (including those of coastal clams, fish, seaweeds, and pearls) will face increasing risk with climate change due to heightened typhoon damage and resulting sedimentation from affected land-based coastal activities. Freshwater aquaculture will face problems of excessively high temperatures, flooding, and drought, but warmer temperatures will also allow more aquaculture at higher elevations (an important consideration in PNG), while well-managed systems may benefit from any additional water flow.[60]

Impacts on Forestry

Future warmer temperatures will likely cause stress in forest trees, leading to defoliation, decline in forest growth, and spread of invasive species, such as vines, that can cause considerable damage to forest areas. Drier conditions will increase the vulnerability of forest areas to fire. Coastal forests are projected to be severely affected by sea-level rise, typhoons, and associated wave surges, which in turn will leave coastal communities and environments exposed and vulnerable to further extreme events.

Sea-level rise could affect growth and productivity of mangrove forests while storms and associated heavy rain can cause pollution, thereby affecting breeding and spawning grounds for many fish species in mangrove areas.

60 Bell, Planning the Use of Fish.

Impacts on Water Resources

Climate change and climate variability will add pressure to current water resources problems, particularly in rural communities where livelihoods depend on water supply. Climate change alters the hydrologic regimes in watersheds, affecting the spatial and temporal distribution and availability of water resources for various purposes, including agricultural production. Future projections of increased temperatures and less rainfall will affect the rate of freshwater recharge; with increasing population, these factors will put pressure on the demand for potable (drinking) water. Water shortages that are already apparent in dry seasons would become more pronounced with climate change. The IPCC concluded that by mid-century, climate change is expected to reduce water resources in many small islands, such as those in the Pacific, to the point where they become insufficient to meet demand during low-rainfall periods.[61]

The consequences of drought can be aggravated by sea-level rise, notably for the effects on groundwater supplies. Increases in sea level could cause saltwater intrusion into shallow groundwater resources in coastal areas, particularly if groundwater recharge is reduced or slowed down or water is overextracted. Increased rainfall often associated with cyclones could also cause flash floods, soil erosion, and further pollution of freshwater and marine environments. With a 2–4°C temperature increase, economic losses are projected to amount to $1 billion in damages to water resources.[62]

Impacts on Human Health

Temperature variation and extreme events strongly influence the epidemic potential of water- and vector-borne diseases such as cholera, typhoid, malaria, and dengue. Rising temperatures and increased humidity create perfect conditions for pathogens to grow and spread, resulting in increased incidence and prevalence of infectious diseases. The risks from water-borne diseases such as cholera and typhoid, and vector-borne diseases such as malaria and dengue, will rise due to increased flooding, and the areas susceptible to communicable diseases will expand. There will be changes in the distribution and frequency of malaria; higher temperatures will enable mosquitoes to reach higher altitudes, where people who have not been exposed will be more susceptible to the disease.[63]

Malaria is a major cause of illness in Melanesia, and climate change may extend the spread of malaria as well as dengue fever. Increased temperatures in PNG, for example, will likely cause a contraction of the cooler malaria-free zone in the highlands. Studies show positive associations between temperature increases and diarrhea, and between warmer sea surface temperatures and ciguatera[64] outbreaks. Heat stress and increased injuries and deaths from extreme events are other likely results.

Storms can also damage and destroy health centers and related infrastructure, disrupting essential health services. With lower agricultural productivity due to climate change, food shortages may arise, causing malnutrition rates to increase. Decreased agricultural production will also have follow-on effects on diet, with more reliance on imported, often less healthy, foods. With health services in most Pacific countries already ill equipped and struggling to cope with existing health problems, there will be less capacity to adequately respond to the increased health burden caused by climate change.

Impacts on Settlements and Infrastructure

The majority of human settlements and critical infrastructure in Pacific countries are located in coastal areas. This includes hospitals, schools, churches, power plants and distribution systems, fuel depots, telecommunication systems, disaster coordination centers, hotels and other tourism facilities, airports, wharves, and commercial structures. It is estimated that coastal flooding will potentially affect between 60,000 and 90,000 people in the region, or 0.3%–0.5% of the projected population, by 2050.

61 Footnote 54.

62 International Fund for Agricultural Development. 2009. *Climate Change Impacts—Pacific Islands*. www.ifad.org/events/apr09/impact/islands.pdf

63 ADB. 2010. *Climate Change in the Pacific: Stepping Up Responses in the Face of Rising Impacts*. Manila.

64 Ciguatera is a foodborne illness caused by eating certain reef fishes whose flesh is contaminated with toxins originally produced by dinoflagellates such as *Gambierdiscus toxicus*, which live in tropical and subtropical waters.

Therefore, any factors that impact coastal areas, such as extreme weather events, coastal erosion, and sea-level rise, would exact a very high human and economic toll. Infrastructure assets will be the most vulnerable sector given the costs of construction and maintenance.[65]

Social and Political Consequences

The systems that support food security are also vulnerable to climate change. Transport infrastructure—roads, transport vessels, piers, etc.—is made up of fragile links that can break during natural disasters and quickly lead to food shortages. Food security also depends on continuing education and public awareness on nutrition, and thus on functioning schools and working communication systems. Trade remains vital in order to import food.

The social and political consequences of climate change come primarily from the potential necessity (and difficulty) of relocating people to higher ground. More than 50% of the population in Pacific countries lives within 1.5 km of the shoreline, and sometimes only less than a few meters above sea level. An increase of as little as half a meter, along with increased storm surges, would inundate many critical areas and threaten their populations. For example, a one-meter rise in sea level in Kiribati and the Majuro atoll in the Marshall Islands will make 12.5% and 80%, respectively, of total land vulnerable.[66] At the same time, loss or degradation of agricultural land will drive more people to cities and towns, increasing the amounts of imported foods needed. If storms increase in intensity as projected, not only will agricultural output be affected, but supplies of imported foods also may be disrupted.

Relocation of people and communities from the coastal areas, either to properties on higher ground or to other islands or countries, has been difficult because of limited availability of areas that are appropriate for settlement and the social and political consequences of migration.

65 ADB, *Climate Change in the Pacific*.
66 IFAD, *Climate Change Impacts*.

Rethinking the Options

"Climate change is likely to increase the number of people at risk of hunger compared with (IPCC) reference scenarios with no climate change; the exact impacts will, however, strongly depend on the projected socio-economic developments, but it is likely that the magnitude of these climate impacts will be small compared with the impact of socio-economic development." (Schmidhuber and Tubiello 2007)

Countries in the Pacific region are already experiencing disruptive consequences of global climate change, including increased frequency and severity of coastal erosion, floods, drought, storm surges, groundwater degradation, saline intrusion, coral bleaching, more widespread and frequent occurrences of vector-borne diseases, and periods of exceptionally high sea levels. As these climate change impacts will increase over time and are likely to threaten food security, the region will need a renewed approach to simultaneously address these twin threats: climate change impacts and food security vulnerability.

While national and regional plans of action for climate change have been in the making for nearly a decade, regional action on food security in the Pacific is only very recent. At the 41st Pacific Islands Forum held on 4–5 August 2010 in Port Vila, Vanuatu, country leaders came up with the Framework for Action on Food Security in the Pacific.[67] The framework provides guidance for future actions, policy directions, and funding decisions on a number of themes covering (i) leadership and cooperation, (ii) regulatory frameworks and public-private sector collaboration, (iii) enhanced and sustainable production of safe and nutritious local food, (iv) protecting vulnerable groups, (v) consumer empowerment and mobilizing partners, (vi) a food security information system, and (vii) cross-cutting issues (e.g., land use policies, energy, transport, education, and communication systems) to underpin food security. Country leaders also endorsed guiding principles in implementing climate change adaptation and mitigation measures and signified their commitment to address food security issues nationally, and where possible regionally, through support for key sectors such as agriculture, fisheries, trade, and transport.

The key country documents guiding climate change adaptation efforts in least developed countries are the national adaptation programs of action (NAPAs). Four such Pacific countries—Kiribati, Samoa, Tuvalu, and Vanuatu—have prepared and submitted their NAPAs to the United Nations Framework Convention on Climate Change (UNFCCC) and used them to frame national adaptation activities. These documents also reflect the need for urgent and immediate adaptation actions in agriculture, fisheries and marine resources, coastal protection, infrastructure, education, and information, among others, especially to reduce potential threats to the country's food security status.

Pacific countries have likewise implemented many sectoral and national policies, programs, and plans that address climate change threats, as well as community-based adaptation and mitigation initiatives. Initial climate-related activities focused on enabling actions to ensure compliance with international reporting requirements related to the UNFCCC. Subsequently, some project activities focused on assessing vulnerability to climate change, identifying appropriate adaptation responses, and building adaptive capacity. Early mitigation efforts were primarily directed toward renewable energy demonstration projects, but these have had limited success in reducing reliance on petroleum imports.

The United Kingdom (UK) Climate Impacts Programme has categorized climate change measures and strategies as either (i) building capacity—creating the information (research, data collection and

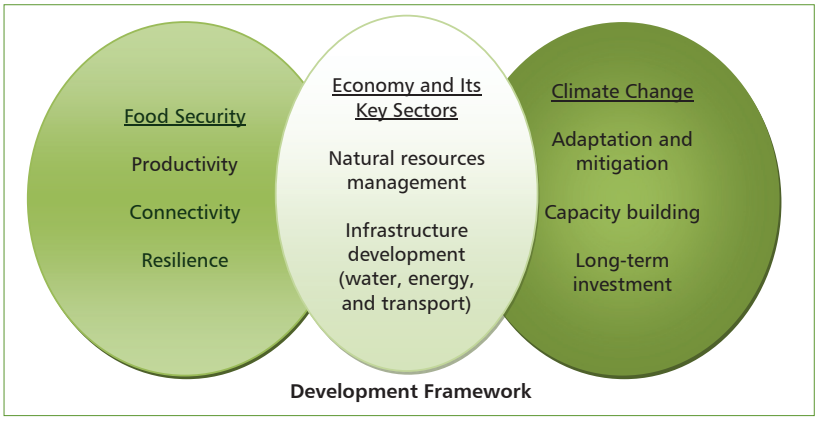
67 Secretariat of the Pacific Community. 2010. *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific*. www.foodsecurepacific.org/documents/FINAL%20TOWARDS%20A%20FOOD%20SECURE%20PACIFIC_June1.pdf

monitoring, awareness raising); supportive social structures (organizational development, working in partnership, institutions); and supportive governance (regulations, legislations, and guidance) that are needed as a foundation for (ii) delivering actions that will help reduce vulnerability to climate risks or exploit opportunities.[68]

Clearly, both climate change and food security concerns are not stand-alone issues but have clear linkages with each other, and bear the influence of economic growth, poverty reduction, status of environment, resource productivity, and improvement of infrastructure and social services, among many others. Therefore, a shift in strategy and rethinking of options will be necessary to develop robust and more comprehensive actions to adapt to climate change and improve food security.

Figure 4 illustrates the stylized interrelationship of strategies for food security and climate change under a common development framework targeting the economy and its key sectors. In the Pacific context, supporting countries in their need to address climate change through building increased resilience in key sectors will also contribute to achieving sustainable food security. Maintaining and improving sectoral performance and removing structural and institutional constraints will together provide the necessary impetus to drive economic growth and ensure food security.

Figure 4: Common Development Framework for Food Security and Climate Change



Source: Author.

The interrelationship would mean the need for (i) investments to develop and manage climate-resilient food production systems, environment, infrastructure, and regulatory measures; (ii) capacity development to enable mainstreaming of food security and climate change into national development plans and programs; and (iii) providing sustained long-term financing, in coordination with other development partners, for investment in infrastructure and institutions that ensures economic growth and food security in the face of climate change.

More specifically, pathways to achieve food security in the Pacific in the face of climate change impacts will involve multiple and simultaneous actions that will (i) promote the local and traditional production and supply base of nutrient-rich food; (ii) emphasize greater community involvement as part of institutional capacity development for implementing food security and climate change adaptation initiatives; (iii) build climate resilience in cross-sectoral development (e.g., transport, road networks, markets) as these are important factors for food production and trade; (iv) widen the role of information, education, and communication; and (v) create safety nets and emergency and disaster response systems.

Productivity Enhancement and Economic Growth

Agriculture remains an important cornerstone to improving food security in many Pacific countries. As such, it will require effective management of the changing context such as urbanization, decline

68 UK Climate Impacts Programme. 2008. Adaptation Types. www.ukcip.org.uk/essentials/adaptation/adaptation-types/

of interest in agriculture, chronic land disputes, and the uncertainties of adapting food production systems to climate change. A greater focus on fish to meet protein shortfalls (while efforts to adapt and improve terrestrial agriculture continue) will also increase food security in the near term.

A 2010 Global Conference on Agriculture Research for Development document stated that "[i]f agriculture is given its due attention and support from the top levels of government, bureaucracy and policy, then all else in terms of social development will follow as farmers become more prosperous."[69] However, a more holistic rural development approach would seem necessary, including institutional strengthening, infrastructure development, and provision of basic social services such as health, education, transport, and markets.

Policies that improve the efficient use of resources (e.g., land, water, and ecosystems) should be promoted to facilitate agricultural growth and enhance food production. A win–win policy here will be the strengthening of traditional and self-reliant agricultural systems through development and implementation of programs with components that encourage growing traditional climate-resilient staple crops such as taro, yam, cassava, and others. In addition, new crops, crop varieties, or production technologies (e.g., crop diversification, modified cropping calendars and/or cropping patterns, updated farming systems) can be adapted to Pacific conditions to help farmers improve on their traditional production systems to secure food and at the same time address their need to adapt to the impacts of climate change. The production and provision of adequate safe and nutritious local food should also be further supported and encouraged, especially since the region's current free trade approach to development tends to increase imports of processed foods—often calorie-rich and nutrient-poor—which could weaken food security.

There are also opportunities to expand the agriculture sector through developing competitive niche markets and products with higher added value. In Solomon Islands, for example, virgin coconut oil is making a substantial contribution to incomes in rural communities whose only coconut crop, until now, has been the lower-value copra. Likewise, the expansion of commercial agriculture, especially coffee and cocoa, has good growth prospects. Coffee is the major cash crop in Timor-Leste and a quarter of households earn an income from it. Other crops with good export prospects include sandalwood and vanilla. However, the prospects and promotion of commodities for nonfood use—like coconut, sugarcane, and cassava as feedstocks for biofuel production—need to be carefully studied and weighed vis-à-vis their impact on the environment and food security.

For the fishery sector, efforts to carefully manage and reduce existing pressures on coastal fisheries will be required to build the resilience of existing fishery resources and habitats to climate change. The productivity of fisheries, especially those products with good export potentials, has to be enhanced, alongside the strict enforcement of fishery regulations to help protect marine and coastal habitats and resources. Pacific countries can also be encouraged and supported to promote marine and freshwater aquaculture as means to secure fish availability as an integral part of food security. In Melanesia, for example, the expansion of tilapia aquaculture could be promoted, especially in freshwater systems where it already exists. A focus on fisheries in food security would require policies ensuring the sustainability of fishery resources; updated cost–benefit analyses and policies on domestic use of offshore tuna harvests; urgent attention to establishing necessary postharvest facilities for cold storage, processing, and distribution; and new mechanisms for interisland sharing or trading of fishery products.

Similarly, sustainable agroforestry should be promoted to help maintain and support forest biodiversity, and forest laws and regulations, especially on illegal logging, should be strictly enforced as well. Benefits from harvests of various forest products can be enhanced by promoting bioprospecting and biodiscovery while increasing productivity. There will be a need to develop comprehensive resource management plans that include initiatives to address the impacts of extreme weather events as well as those of exploitative human activities. Reforestation and diversification of forest species ought to

69 Quartermain, A.R. 2009. *GCARD 2010 Pacific Sub-Regional Report: Transforming Agricultural Knowledge into Development Impact for the Pacific*. Global Conference on Agricultural Research for Development. www.fao.org/docs/eims/upload/273549/pacific-sub-regional-report.pdf

be encouraged. For example, whitewood, which is believed to be highly resistant to natural disasters, can be propagated side by side with sandalwood for the sustainable protection and management of indigenous forest areas.

An element of agricultural development is commodity market development, including the promotion of effective forward and backward linkages of the food supply chain. Innovative institutional and contractual reforms (contract farming schemes, land-lease arrangements, nucleus estate arrangements, etc.) that efficiently and effectively link the forward and backward activities (i.e., the input markets to production, processing, and marketing in domestic and international markets) have to be encouraged. Strong partnerships can be promoted among private and public entities and local organizations and in multilateral agreements. At the same time, efficient financial services that would improve access to credit for production and other business ventures have to be set up to encourage greater participation of the private sector.

While strong emphasis is placed on the demand-side measure to ensure food security through poverty alleviation, investment in the supply side appears to be insufficient at the global level. Development aid aimed at agriculture decreased by 58% in real terms between 1980 and 2005, indicating that external assistance for agriculture in recent years has been weak.[70] The need to enhance food production and security is a strong justification for substantial increases in agricultural investment in research and development, infrastructure, and extension and training in the agriculture, forestry, and fishery sectors that specifically consider the context of Pacific countries. This can include, among others, the (i) identification or introduction and use of improved and/or stress-resistant (e.g., from insect pests, diseases, salt, and drought) crop varieties and/or livestock species; (ii) promotion and sustainable exploitation of underutilized species and resources; (iii) development of new farming systems and coastal management strategies; (iv) expansion of cultivated areas and/or better land management practices (to help curb the effects of population pressure and climate change on food production); (v) development of production technologies for rainfed areas; and (vi) development of appropriate postharvest (processing and value-adding) technologies. Investment in agriculture, including development of related infrastructures, will be necessary to address potential food demand–supply imbalance, and is therefore a prerequisite to food security.[71]

Gaps in data and knowledge about island systems contribute significantly to the difficulty faced when identifying options for adaptation. While global scenarios, such as those related to temperature increases and sea-level rise, are sufficient to assess global actions to address climate change, similar scenarios at the island scale are often so uncertain that adaptation assessments frequently lack credibility with decision makers. Improved data and knowledge pertaining to the physical and economic impacts of adaptation and climate risk-reduction measures are still limited. Some climate change parameters that ought to be carefully monitored for current and future planning purposes include temperature (warm and cold nights), precipitation, sea level change, solar radiation, soil fertility, soil and water salinity, and the occurrence of extreme events (e.g., El Niño and La Niña episodes). More importantly, climate information must be managed, analyzed, and developed into effective communication and knowledge products that can be easily understood by stakeholders, especially farmers and fisherfolk.

Institutional Capacity Development

Institutional capacity development to manage programs and initiatives will be a major tool and a more effective response to the increasingly urgent need to improve food security amid the changing climate scenario in the Pacific. A 1980 ADB review observed that "[s]mall-scale societies cannot maintain the wide range of specialist roles and the division of labor found in large societies" and that "[p]roducing the accounting and other information required by different aid agencies has meant a great increase in

70 APEC Food Security Ministerial Meeting. Niigata Declaration on APEC Food Security. Niigata, Japan, 16–17 October 2010, as cited in ADB. 2011d. Food Security in the Asia–Pacific *Finance, Food, and Fuel Monitor*. 29 July.

71 ADB, Food Security in the Asia–Pacific.

the workload of the small number of officials concerned in each country. In some countries, a major cost of external aid is the constraint which such involvement places on the productivity of important sections of the civil service."[72] That is, sufficient domestic capacity for institution building and efficient management of some government roles, such as those needed for implementing food security and climate change programs, will be difficult to maintain in those economies that are too small to support large bureaucracies and multiple institutions.

An alternative is for countries to work closely with relevant regional agencies, especially those coordinated by the Council of Regional Organizations in the Pacific. Small core teams in governments could oversee coordination and efficient implementation of climate change and food security programs while drawing on knowledge, technology, and extension services from the regional organizations. These core teams within the governments could, for example, ensure that country development projects in food security and climate change are well conceptualized, efficiently coordinated, and effectively implemented.

The bulk of Pacific populations reside in Melanesian countries and, apart from Fiji, the vast majority is rural and involved in subsistence or traditional economies. As such, efforts to promote climate change adaptation and food security through sustainable resource utilization and livelihoods can be pursued through the local custom economy.

Traditional Pacific societies know food insecurity well, and while climate change is an alien concept, it is, in fact, an extension of the climate variability to which they have adapted over time, mainly through communal mechanisms in which all the people were direct stakeholders. A 2009 ADB evaluation of the effectiveness of its support for public sector reforms in the Pacific concluded, among other things, that "[r]eforms introducing modern systems needed to better consider historical, social, and cultural traditions and context in design and implementation."[73]

Because most Pacific populations remain rural, following traditional patterns of culture and agriculture, it may be fruitful for governments to provide more leeway for communal cultural practices and non-state mechanisms to take the lead in food security matters, and to encourage greater community involvement in decision making. Stronger community leadership would automatically make issues related to food security the concern of all residents, which would improve the adoption rates of new or adapted agricultural and fishery practices. This type of community ownership would provide the means to disseminate and enforce agreed-upon regulatory measures to ensure sustainability of climate-adapted food production systems, which is currently often difficult in the Pacific due to inadequate government institutions and capacity. The widespread disputes regarding ownership and lease of customary land might be more easily solved, paving the way for some agricultural expansion.

Local communities must be involved at all stages of developing adaptation interventions. Appropriate action at the local community level should be pursued to forge and strengthen genuine partnerships. Civil society (micro-level nongovernment organizations, community associations, microenterprises, and civil defense and disaster response groups) must also be engaged in adaptation mainstreaming to reduce community vulnerability and ensure bottom–up ownership of risk management actions and transformational adaptation projects. To help achieve an effective cross-sectoral development framework, a strong and effective institutional setup would be needed to coordinate efforts from various entities and all stakeholders.

Overall, efforts to build capacity for agriculture have to be intensified across the Pacific region. There is a critical need to enhance human resource capacity for sustainable resource management and monitoring as well as for the implementation of cost-effective adaptation and mitigation responses, in view of their impacts and consequences on food security. There is also a great need for stronger formal extension services and new community extension models that will help enhance the adoption of new and improved climate change adaptation options and food production technologies.

72 ADB, Food Security in the Asia–Pacific.

73 For example, Clifford, W., L. Morauta, and B. Stuart. 1984. *Law and Order in Papua New Guinea: Report and Recommendations*. Port Moresby: Institute of National Affairs and Institute of Applied Social and Economic Research. Quoted in Seta, T. 2008. Pacific Choice. Bridging the State–Society Gap: The Community Justice Liaison Unit of Papua New Guinea. *Pacific Studies Series*. Manila: ADB; and Duncan, R., ed. 2010. The Political Economy of Economic Reform in the Pacific. Executive Summary. *Pacific Studies Series*. Manila: ADB. http://beta.adb.org/sites/default/files/political-economy-economic-reform-pac.pdf

Building Climate Resilience in Cross-Sectoral Infrastructure Development

The importance of fully mainstreaming climate change activities in national planning and policy formulation, and closely examining tradeoffs among equally important development goals and objectives, including food security and poverty reduction, cannot be overemphasized. A key element will be designing cross-sectoral policies and initiatives that consider the intricate relationship between climate change and food sources and how it affects society and the economy. Harnessing the benefits of cross-sectoral development that enhances growth, productivity, trade, and distribution should be an integral part of improving food security in the Pacific region.

Investments in climate-resilient infrastructure development, such as land management, water supply, roads, shipping ports, and coastal development, can increase regional and national connectivity, productivity, and food security. Climate proofing has to be mainstreamed to incorporate climate change adaptation features into project planning and engineering designs. Climate-proofing development projects means identifying and reducing the risks posed by extreme weather events to acceptable levels through long-lasting, environmentally sound, economically viable, and socially acceptable changes.

The focus of cross-sectoral development investment should be to protect and enhance the resource-based infrastructure that creates and maintains competitive and comparative advantages for agriculture and food production and trade. The scope of such investment should focus on the following:

- **Natural resource management, including agriculture and rural development**, with emphasis on (i) coastal and marine resources protection and management; (ii) integrated watershed management including sustainable forestry management and wildlife management; (iii) building synergy between adaptation and mitigation; and (iv) pursuing proactive measures in anticipation of climate change (e.g., improved soil and water management, diversification and intensification of food and plantation crop production, developing approaches to intensive commercial agriculture, and strengthening land use planning for production of key commercial and subsistence crops).
- **Water**, focusing on (i) flood control; (ii) drainage and sanitation; (iii) rural and urban water supply; and (iv) integrated water management, including improved catchment management (reforestation, soil conservation, wetland protection and management, and land use management) and reducing disaster risks from flooding by regulating development on floodplains and promoting floodproof building design.
- **Energy**, by investing in efficiency solutions that can include energy conservation and demand management; renewable energy deployment; and reduction of greenhouse gas emissions from transport, solid waste and wastewater systems, and land use.
- **Transport**, consisting primarily of climate proofing of roads, ports, and airports; reduction of greenhouse gas emissions from transport through demand management and the use of clean energy in vehicles; and limited investments in alternative and cleaner fuels (e.g., biofuels development).

The facilitation of investment, trade, and markets also poses challenges that impact food security. Food security cannot be achieved without stable, efficient, and equitable distribution systems as well as reliable markets that can deliver food to the whole population. The governments of Pacific countries should provide the necessary facilities and infrastructure to integrate and expand trade. To maintain long-term growth in the agriculture sector, they should improve the agribusiness investment environment by promoting policies that encourage the development of micro, small, and medium-sized agro-enterprises, and by addressing bottlenecks that impede their operations. There are also substantial gains from regional cooperation through policy coordination, cross-border trade facilitation, and intervention when policies, institutions, or markets fail.[74]

Information, Education, and Communication

Strategies and programs for improving information, education, and communication have important roles to play in ensuring food security and climate resilience in Pacific countries. Opportunities for climate change

74 ADB, Food Security in the Asia–Pacific.

adaptation include the design and maintenance of a climate risk-informed decision support system using geographic information system (GIS). The application of GIS methodology in impact and vulnerability assessments will help optimize the planning and design of crucial adaptation investment projects. In relation to this, downscaled analyses of climate data should be pursued, because many uncertainties remain on the nature and extent of climate changes in specific geographic areas in the Pacific.

The dissemination of improved data and information will be critical to raise public awareness and understanding of climate change issues and the potential impacts on food production and food security. Public education on climate change impacts and adaptation, and their relationship with food production and security, should be promoted. Educational curricula at all levels should be strengthened to include disaster risk reduction and climate change adaptation. It will also be important to facilitate interisland and regional information exchange on, and encourage the replication of, best practices and lessons learned from adaptation activities and food security strategies.

Public awareness about global warming is improving through the media, but public awareness about the impact of climate change on peoples' livelihoods is extremely limited. Such awareness and understanding will be crucial in fostering effective partnerships with local communities for climate change adaptation and mitigation efforts.

Effective Disaster Management and Emergency Response System

Another important aspect of ensuring the availability of food in the Pacific is effective assistance, especially in the event of disasters and emergencies. Often targeted and freely distributed to victims of natural or human-made disasters, emergency food supplies and disaster assistance are designed to respond to the immediate needs of affected populations in the event of temporary or cyclical calamities and/or crop losses. However, disaster and emergency assistance should go beyond immediate provision of food and other basic needs, such as clothing and medicines. Other options for assisting disaster-affected communities include weather-based crop insurance, emergency input subsidies, and provision of some agricultural support fund.

Weather-based crop insurance aims to mitigate the hardship of insured farmers in the event of crop loss due to adverse weather conditions. While crop insurance specifically indemnifies the farmer against shortfall in crop yield, weather-based crop insurance is based on the fact that weather conditions affect crop production even when a farmer has taken all the care to ensure good harvest. Payout structures are developed to compensate farmers to the extent of losses deemed to have been suffered using weather thresholds (i.e., weather parameters beyond which crops are adversely affected). In other words, weather-based crop insurance uses weather parameters as a proxy for crop yields in compensating farmers for deemed crop losses.[75]

Farming communities can also be provided with emergency input subsidies to give them ready access to cheaper production inputs and help them recover production lost due to climate-induced disasters. Governments can also provide disaster-affected communities with an agricultural support fund (credit, soft loans, insurance, etc.) for the same purpose.

Disaster risk management should be approached in an integrated manner, combining disaster risk reduction, elements of climate change adaptation, and disaster risk financing. Pacific countries should be supported in developing their capacities to more proactively manage disaster risk at the national and community levels, thereby yielding greater opportunity to reduce vulnerabilities, enhance climate resilience, and respond faster to impacts. Key options for disaster risk management therefore include reducing exposure of countries and communities to the risks and impacts of extreme climate events; developing or enhancing integrated early warning and response systems and disaster preparedness information systems; and strengthening the resilience of vulnerable communities.[76] It should be noted that disaster management and emergency response systems both warrant proper governance and program implementation, including institutional accountability and transparency.

75 India Development Gateway. Agriculture. www.indg.in/agriculture/schemes/weather-based-crop-insurance-scheme-wbcis (accessed 30 July 2011).

76 ADB. Disaster Risk Management. www.adb.org/Disaster/default.asp (accessed 31 July 2011).

Implications for ADB Assistance

Attaining food security and adapting to and/or mitigating the impacts of uncertain future climate in the Pacific are not stand-alone issues; they have clear synergies with each other as well as with other important national issues and concerns. They need to be approached in the overall development context and through economy-wide and sector development planning and implementation, for which appropriate and sustained financing sources should be identified. The adoption of a "no regrets" adaptation strategy to ensure food security in the Pacific region will need the backing of sound policies that enable robust and best-practice measures to be implemented efficiently and effectively.

On a broad front, climate change and food security issues in the Pacific can be addressed through increased and sustained production; economic growth; capacity development; information, education and communication; and/or cross-sectoral development, among others. A number of development partners have been responding to these needs in the Pacific region. However, actions on the ground to date have been generally fragmented and uncoordinated, in part because all are required to develop organization plans according to their own political and financial situations and budgetary timetables.

As a major development partner of the Pacific countries, ADB is committed to providing investment and technical support for measures that will ensure continued economic growth and food security in the face of climate change, including assisting in the countries' access to various financing facilities. Strategy 2020,[77] ADB's long-term strategic framework, provides significant scope for environmentally sustainable and climate-resilient cross-sectoral and inclusive development to promote economic growth and enhance food security among developing member countries (DMCs) in Asia and the Pacific. Appendix 4 presents the close synergy of ADB's approach to food security and climate change with the Pacific leaders' 2010 Framework for Action on Food Security in the Pacific.

In consultation with the 14 Pacific DMCs, ADB has developed the Pacific Climate Change Implementation Plan[78] and a supporting action program, the Pacific Climate Change Program (Box 2). While these programs are more explicitly geared toward improving development partner response and making funding accessible for Pacific DMCs to respond to climate change and variability, program coverage and features addressing the countries' vulnerability to food insecurity are inherent.

Addressing Climate Change

First, immediate attention should be given to fast tracking and scaling up climate change adaptation and mitigation investment that initially focuses on development of adapted, energy-efficient food production systems, including fisheries, for domestic consumption purposes under projected climate change conditions. Resource (land, water, forests, and aquatic systems) management elements could be prioritized in parallel to enable sustainable agriculture to thrive. As noted in Chapter 4, this could be done through promoting community ownership to ensure that management measures are appropriate and can be peer-regulated.

Second, the limitations associated with small populations in most of the Pacific countries suggest a close initial focus for capacity building relevant to food production rather than an effort aimed broadly at all sectors related to climate change. Targeting agriculture and fishery research and development institutions (mainly regional), community groups, and national and local producers may

77 ADB. 2008. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank, 2008–2020*. Manila.
78 ADB, Mainstreaming Climate Change.

be more fruitful than targeting higher-level national institutions. However, high-level decisions will be continually needed to (i) influence the direction and pace of economic development (for example, in light of recent and possible future food price crises) as climate change progresses, and (ii) to address the complex requirements of regional and international cooperation, conservation, and biodiversity agreements. While fostering regional advisory processes, attention to assisting national sector agencies is also critical. Other areas that will require attention in terms of capacity development to improve food security in the Pacific in the face of climate change include education, health, and the effects of urbanization on food production and poverty.

Box 2: Pacific Climate Change Program

ADB established the Pacific Climate Change Program (PCCP) in 2010 to ensure continued economic growth of Pacific developing member countries by reducing their vulnerability to the risks and impacts of global climate change. The program is intended to provide support and building blocks for a multidonor platform to help answer the Pacific countries' present and future climate change–related needs, building on and enhancing the efforts of individual development partners.

The PCCP has the following three-pronged strategy to respond to climate change–related needs:

- Give immediate attention to fast tracking and scaling up climate change adaptation and mitigation investment.
- Build capacity in sector agencies and communities to enable integration of climate change into national development plans and programs.
- Promote more coordinated and harmonized development partner responses, sharing best practices, and helping Pacific countries access funding from other global financing facilities.

The PCCP will focus on the following priority sectors:

- natural resource management;
- agriculture and rural development;
- water;
- energy, and
- transport.

Source: ADB.

If traditional and self-reliant agricultural systems are to be promoted, the development of rural infrastructure, including markets and distribution channels (roads, minor ports, etc.), should also be prioritized. The third prong, long-term investment, answers the need to improve and climate proof vital infrastructure that will maintain and foster economic growth. In particular, water supply improvements are needed in some countries for domestic use and agriculture development. Water and sanitation in urban, especially coastal, areas are also vulnerable to climate change and in many cases already in need of improvement. Related urgent needs for climate-proofed infrastructure are in the transport sector (roads, ports, vessels, air transport) and in communications. Investment in clean energy to replace expensive fossil fuel will help mitigate the Pacific's contribution to climate change as well as reduce the cost of commodities, including food.

ADB has already begun to mainstream climate change activities into its operations and will continue to identify and implement appropriate solutions-based interventions. It is one of the few development partners in the region providing a combination of technical assistance, grants, and loans; it is also an implementing agency of the Global Environment Facility (GEF), which funds activities that promote global environmental benefits while strengthening local environmental management. ADB also provides access to the Climate Investment Funds. A Pacific regional climate resilience program supported by ADB is one of the first to be developed under the Pilot Program for Climate Resilience, financed by the Strategic Climate Fund (one of the two funds within the design of the Climate Investment Funds).

ADB has long been working with the World Bank in assessing the feasibility of establishing a Pacific Catastrophe Risk Insurance Facility under the Pacific Islands Disaster Risk Reduction and Disaster Management Framework for Action (2005–2015). ADB is mainly responsible for setting up a database on the countries' exposure to natural hazards,[79] which will feed the modeling work on catastrophe risk insurance prepared by World Bank. Results from the modeling activities will determine the insurance pay-out, and can also be used for government planning purposes. The regional technical assistance covers eight countries namely, the Cook Islands, Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

A fundamental aspect of ADB assistance will be improving the coordination of development partner response and helping make global funds readily accessible to Pacific countries through a programmatic approach that will help the countries reduce their vulnerability to the impacts and consequences of climate change and pursue a more food secure future. Appendix 5 shows some ongoing and pipeline ADB projects addressing or relating to climate change in the Pacific region.

Opportunities in Sector Investments

In view of the diversity in the climate change–related adaptation and mitigation needs of Pacific countries and the current state of their enabling environments for adaptation, the Pacific Climate Change Program focuses on selected priority sectors: natural resources management (including agriculture and rural development), water, energy, and transport. Natural resource management will focus on agriculture and rural development, coastal and marine resources protection and management, integrated watershed management, and building synergy between adaptation and mitigation. A broad spectrum of coastal and marine protection options will be considered and tailored to be implemented at the community level.[80] Further investment in the creation and protection of natural marine buffer zones, such as mangrove rehabilitation and reforestation and coral reef protection and management, will be analyzed, especially in high-risk coastal areas vulnerable to sedimentation, erosion, and coral bleaching due to changing climate. The "ridge to reef" approach to integrated natural resource management has the added advantage of capturing better synergies between adaptation and mitigation responses, such as the conservation, protection, and management of forests to serve as carbon sinks for greenhouse gas emissions. For example, an ADB–GEF partnership will provide regional technical assistance to help ensure food security in five Pacific Coral Triangle Initiative countries through more effective management of coastal and marine ecosystems, thus building their resilience against increasing threats from climate change impacts (Box 3).

Agricultural adaptation for the Pacific could include proactive measures in anticipation of climate change, such as (i) development of tolerant/resistant crops (to drought, salt, insect pests, and diseases); (ii) research on more flexible farming systems that are tolerant to climate variability, and establishment and maintenance of gene banks and planting materials, including drought- and saline-resistant crops; (iii) improved soil and water management; (iv) diversification and intensification of food and plantation crops; (v) development of approaches to intensive commercial agriculture; and (vi) strengthened land use planning to improve the identification of areas most suitable for key commercial and subsistence crops. There is also a need for improved understanding of the impact of climate variability on cropping and tillage patterns and on income and employment structures, which can then lead to specific agri-adaptation strategies. This will require technical assistance for natural resource and climate modeling to assist development planning and decision making. These adaptation measures could be piloted in countries like Kiribati, the Marshall Islands, Samoa, Timor-Leste, and Tonga, where substantial areas are utilized for agricultural production.

Adaptation assistance in the water sector could address focus on flood control, drainage and sanitation, rural and urban water supply, and integrated water resource management, including improved catchment management (reforestation, soil conservation, wetland protection and

79 ADBb. 2008. *Regional Partnerships for Climate Change Adaptation and Disaster Preparedness*. Manila.
80 ADBa. 2009. *Environment Program: Progress and Prospects*. Regional and Sustainable Development Department. Manila.

management, and land use management). Disaster risks from flooding due to extremely high rainfall, storm surges, and tropical cyclones could be reduced by regulating development on floodplains and promoting floodproof infrastructure design. Early warning systems and community-based emergency preparedness and response systems, including those for waterborne diseases, will also be considered. In general, the water sector initiatives are designed to cope with the impacts of climate change by reducing water losses and applying integrated water resources management to improve the resilience of communities and economies to climate change, which contributes to ensuring their food security.

Box 3: Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (Phase 2)

What is the Coral Triangle?

The Coral Triangle is the center of the world's coral reef biological diversity, holding more than 75% of the known coral species and more than 3,000 species of reef fish. It covers 5.7 million square kilometers and includes all or part of the exclusive economic zones of six countries spanning Southeast Asia and the Pacific. The Coral Triangle contains vast marine resources critical for economic and food security of an estimated 120 million people.

Key coastal and marine resource management issues identified in the Coral Triangle include (i) overexploitation of coastal areas and overharvesting of valuable species, (ii) climate change impacts, (iii) weak management of natural resources systems, and (iv) extremely limited staff and budgetary resources and capacity for public sector environmental management programs. All these are exacerbated by high rates of population growth and rural poverty, creating food insecurity concerns.

Partnership between ADB and the Global Environmental Facility

In response, ADB and the Global Environment Facility will help ensure food security in five Pacific Coral Triangle Initiative countries (Fiji, Papua New Guinea [PNG], Solomon Islands, Vanuatu, and Timor-Leste) by addressing the need to increase the resilience of coastal and marine ecosystems. It will support the introduction of more effective management of coastal and marine resources to build their resilience in a period of increased threats arising from human activities and climate change impacts. The technical assistance will contribute toward halting or reversing the expected decline in ecosystem productivity caused by these stressors through more effective management that addresses land and water interactions and the management of threats to coastal habitats arising from local human activities. By maintaining productivity over a longer time frame, local community well-being will be ensured. The technical assistance will be implemented over a 4-year period commencing on 1 January 2011 and ending on 31 December 2014.

Executing Agencies

(i) Fiji: Department of Environment under the guidance of the Integrated Coastal Management Committee; (ii) PNG: Department of Environment and Conservation; (iii) Solomon Islands: Ministry of Environment and Conservation Management and Ministry of Fisheries and Marine Resources; (iv) Timor-Leste: National Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Fisheries; and (v) Vanuatu: Department of Environment, Ministry of Lands and Natural Resources.

Source: ADB. 2010c. *Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (Phase 2)*. Approved 14 December 2010.

For the energy sector, mitigation is a far lower priority in the Pacific region, where adaptation to the impacts of climate change are a far more pressing issue than the delivery of global environmental benefits through the reduction of greenhouse gas emissions. Nonetheless, there is value in investing in emissions reduction solutions, which simultaneously provide greater energy security and increase economic competitiveness in the Pacific. These solutions include energy conservation and efficiency (supply- and demand-side measures); renewable energy deployment; and reduction of greenhouse gas emissions from transport, solid waste and wastewater systems, and land use.

Adaptation measures in the transport sector could include climate-proofing infrastructure such as roads, ports, and airports. Climate-proofing development projects means identifying and reducing

the risks posed by extreme weather events to acceptable levels through long-lasting, environmentally sound, economically viable, and socially acceptable changes. In line with the ADB Climate Change Implementation Plan's recommendation to mainstream climate change issues into ADB operations in the Pacific and in the individual Pacific DMCs, projects in the region are already being climate proofed—that is, climate resiliency–building measures are being incorporated into infrastructure projects with climate risks. Meanwhile, mitigation measures may involve the reduction of greenhouse gas emissions from transport through the use of clean and/or renewable energy in vehicles. Limited investments could also be made in alternative and cleaner fuels, such as biofuel development. Significant clean energy initiatives are currently programmed for ADB developing member countries in the Pacific.

Ensuring Food Security

In the highly vulnerable and already hard-hit Pacific region, responses to the impacts of climate change, especially on food security, will be more effective through a concerted and coordinated multisectoral response, based on a comprehensive understanding of the countries' needs and capacities. The Pacific island governments view climate change as a priority issue, but need clear objectives in addressing its impacts. ADB is in a position to analyze the complex problems at all levels; identify appropriate solutions based on the varied geographic, social, and environmental conditions; and mobilize technical and financial assistance to implement solutions in a holistic manner.

ADB's *Operational Plan for Sustainable Food Security in Asia and the Pacific*[81] prioritizes achieving sustainable food security as a crucial element of its vision of having the Asia and Pacific region free from poverty. The operational plan identifies ADB's role and contributions in addressing constraints to achieving sustainable food security, and for which its core and other areas of interventions have made significant contributions. Investments in irrigation development and/or modernization, improved management of natural resources, and enhanced access to financial services and products are good examples of ADB's core operations that address productivity constraints (Table 17). Similarly, investments in transport infrastructure, trade facilitation, and promotion of small and/or medium-sized rural enterprises help address connectivity constraints significantly, while investments in disaster risk management (e.g., flood dikes), food safety nets, nutrition, and vocational training address the resilience constraints. Notably, some of ADB's areas for intervention to achieving food security also relate to climate change adaptation and mitigation.

Support Interventions

ADB aims to support projects already identified and prioritized in the national development plans of Pacific countries and in the current portfolios of ADB and international and regional development partners. ADB's assistance related to the climate change and/or food security strategies and priority sectors as described above may be accompanied by any or all of the following supporting activities:

- policy and legal reform to enable the effective implementation of climate adaptation initiatives through enforcement of supporting policies, laws, and regulations;
- capacity building of concerned institutions, including the private sector and civil society organizations, to strengthen or upgrade their knowledge, skills, attitudes, and practices in various climate-related fields (e.g., vulnerability or risk assessment; climate proofing of policies, plans, and projects; incremental analysis of climate change adaptation; climate-oriented environmental assessment); and
- public awareness and information, education, and communication campaigns directed at the general public and policy and decision makers to ensure the wider involvement of various stakeholders and the effectiveness of the climate change–related interventions.

81 ADB. 2009d. *Operational Plan for Sustainable Food Security in Asia and the Pacific*. Manila. www.adb.org/Documents/Reports/Sustainable-Food-Security/default.asp

Table 17: ADB Areas for Food Security Intervention

Sector	Areas for Intervention
Infrastructure	▪ Water productivity (irrigation, drainage, and water storage) ▪ Access to public infrastructure services (rural roads, rural electrification, market infrastructure, and rural town development) ▪ Resilience against natural disasters (flood and drought risk management)
Environment	▪ Integrated water resources management ▪ Climate change mitigation and adaptation (e.g., biogas, rural renewable energy, natural resource management)
Regional cooperation and/or integration	▪ Food and agriculture trade ▪ Food safety and standards ▪ Regional emergency food reserve system ▪ Cross-border water resources management ▪ Regional disaster risk management
Finance	▪ Access to micro credit and rural finance services ▪ Rural enterprise development ▪ Resilience against emergencies (risk insurance and safety net)
Education	▪ Skills development (vocational training)
Agriculture	▪ Small farmers' access to markets (food and agricultural value chain facilitation) ▪ Agricultural research and dissemination of innovative knowledge and technology
Health	▪ Nutrition status of women, children, and the poor
Disaster and emergency assistance	▪ Early warning and information systems

Source: ADB. 2009d. *Operational Plan for Sustainable Food Security in Asia and the Pacific*. Manila. www.adb.org/Documents/Reports/Sustainable-Food-Security/default.asp

Ensuring successful food security and climate change programs, projects, and initiatives depends on acceptance and administration at the national and subnational levels. ADB works to strengthen good governance and policies in support of climate change mitigation and adaptation and to ensure economic growth and food security. Capacity building is bolstered at many levels, from assisting government ministries in crafting supportive policies to helping country stakeholders better understand the science and good practices required to properly respond to country-specific needs.

The next 10–15 years is the generally agreed window in which the international community must mobilize global financing and put long-term adaptation (and mitigation) plans in place. While the majority of least developed countries has already prepared NAPAs, their implementation will be a challenge. Many adaptation measures will focus on strengthening measures that already exist, such as early warning systems and disaster risk management. Others will focus on rural investments to reduce the long-term impacts of short-term climate variability on food security, for example through crop insurance. Policies need to be integrated across levels and sectors and should take advantage of potential synergies between climate change adaptation and mitigation as well as food security and sustainable development. It will be important for national constituents to regularly and actively participate in international climate change negotiations and forums.

Lastly, the technical and policy measures to ensure food security amid the ensuing impacts and consequences of climate change are numerous, interrelated, and complex. Some are long-term and contingent on further proof of climate change impacts. Others, however, need to be pursued with urgency to help cushion the expected more immediate economic and social impacts. Climate change adaptation measures such as the strengthening of traditional farming systems, development of early warning and risk preparedness systems, and policy recommendations that promote efficient use of resources and promote open and transparent trade will have to be prioritized despite remaining uncertainty regarding climate change impacts. The rest can be prioritized based on the results and findings from further analysis and generation of information.

A key point to remember for ensuring the successful implementation of programs and projects is to design them to be as simple and flexible as possible, and to carefully consider the implementation and management capabilities of relevant stakeholders at all levels—regional, national, and local. The programs and projects should be practical, applicable, less complex, and more focused. The increased availability of relevant information and additional analysis on key issues will greatly help in formulating specific recommendations for climate adaptation and mitigation policies that will ensure a longer-term and more sustainable food security status for the Pacific countries.

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Appendixes

Appendix 1: Food Crops and Livestock Production, Pacific Region

FOOD CROPS PRODUCTION, AREA HARVESTED AND YIELD							
	1960s	1970s	1980s	1990–1994	1995–1999	2000–2004	2005–2008
Production (tons)							
Coconuts	1,635,349	1,771,250	2,029,539	1,677,447	2,074,041	1,704,401	1,801,727
Oil palm fruit	1,111	103,833	515,944	979,027	1,148,318	1,369,200	1,517,500
Cassava	153,638	128,190	154,841	165,200	186,182	188,728	221,194
Roots and tubers, nes	221,372	259,438	295,671	309,512	322,601	356,274	367,945
Yams	178,797	212,755	244,239	250,891	253,032	310,011	340,265
Taro (cocoyam)	243,062	264,624	296,346	269,937	258,878	343,066	407,633
Sugar cane	2,188,983	2,644,161	3,747,607	4,049,542	3,855,660	3,564,812	3,142,762
Rice, paddy	20,287	23,640	30,603	24,287	19,009	20,069	20,086
Maize	1,529	1,628	3,276	5,269	8,113	8,703	8,883
Sweet potatoes	367,513	462,686	522,406	536,899	548,677	594,031	660,286
Potatoes	185	670	539	438	532	820	978
Fruits	836,752	1,046,892	1,208,831	1,450,435	1,662,387	1,875,760	2,093,993
Vegetables	213,143	270,732	354,071	428,665	484,561	565,729	581,695
Area Harvested (ha)							
Coconuts	424,349	429,320	460,291	497,866	516,386	460,700	449,860
Oil palm fruit	61	6,506	34,946	58,204	71,800	87,800	102,000
Cassava	15,081	12,080	14,957	15,480	16,428	16,786	18,630
Roots and tubers, nes	15,128	18,467	24,001	26,335	25,504	27,836	28,985
Yams	12,208	13,355	14,326	14,718	14,560	18,355	20,750
Taro (cocoyam)	33,754	37,228	40,997	41,015	38,429	46,584	51,685
Sugar cane	41,556	48,967	70,367	78,097	76,381	71,001	64,126
Rice, paddy	11,023	10,973	13,120	10,775	8,248	7,825	7,685
Maize	1,253	1,682	2,600	3,097	3,151	3,080	3,503
Sweet potatoes	81,314	94,886	102,859	105,257	107,196	110,299	119,403
Potatoes	53	219	129	88	116	172	210
Fruits	87,697	105,192	118,532	135,500	156,344	176,888	194,571
Vegetables	20,263	25,337	33,193	39,999	44,971	51,561	53,519
Yield (tons/ha)							
Coconuts	3.85	4.12	4.43	3.37	4.02	3.69	4.01
Oil palm fruit	18.18	16.46	15.05	16.76	15.99	15.64	14.88
Cassava	10.18	10.60	10.35	10.70	11.35	11.24	11.87
Roots and tubers, nes	14.64	14.05	12.41	11.77	12.65	12.80	12.69
Yams	14.65	15.93	17.05	17.05	17.37	16.91	16.40
Taro (cocoyam)	7.20	7.11	7.23	6.59	6.73	7.35	7.90
Sugar cane	52.52	53.63	53.20	51.90	50.22	50.22	48.92
Rice, paddy	1.84	2.15	2.33	2.26	2.33	2.57	2.61
Maize	1.08	0.95	1.27	1.70	2.60	2.82	2.54
Sweet potatoes	4.52	4.87	5.08	5.10	5.12	5.38	5.53
Potatoes	3.57	3.50	4.28	4.98	4.62	4.78	4.66
Fruits	9.53	9.95	10.20	10.70	10.63	10.60	10.76
Vegetables	10.51	10.68	10.67	10.72	10.77	10.97	10.87

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Appendix 1: Food Crops and Livestock Production, Pacific Region (*cont.*)

GROWTH RATES (%)							
	1960s	1970s	1980s	1990–1994	1995–1999	2000–2004	2005–2008
Production							
Coconuts	1.05	1.20	(1.22)	0.22	5.44	(2.92)	1.07
Oil palm fruit	12.50	82.56	12.50	10.60	2.35	2.67	2.58
Cassava	2.07	(2.32)	2.58	2.40	0.61	2.79	3.26
Roots and tubers, nes	2.02	1.47	1.08	0.18	1.61	1.81	0.19
Yams	2.53	1.43	1.20	(0.88)	1.75	3.81	2.36
Taro (cocoyam)	2.08	0.80	0.55	(3.44)	3.33	5.83	1.71
Sugar cane	11.56	6.74	6.06	0.31	2.75	(3.73)	(4.37)
Rice, paddy	(1.37)	4.61	2.15	(9.69)	4.69	(0.95)	(2.60)
Maize	31.15	14.92	2.90	17.18	3.70	(0.10)	4.68
Sweet potatoes	1.40	2.03	1.00	0.18	1.48	1.77	2.39
Potatoes	36.63	15.43	(2.52)	1.54	9.62	5.51	2.81
Fruits	2.48	1.97	1.90	2.65	2.73	2.25	2.44
Vegetables	3.35	2.63	2.63	2.73	3.49	1.66	0.28
Area Harvested							
Coconuts	0.68	0.33	0.77	0.77	0.34	(2.92)	0.94
Oil palm fruit	12.50	86.71	13.91	8.12	2.57	4.35	2.82
Cassava	1.57	(2.17)	2.21	1.81	0.35	2.44	2.22
Roots and tubers, nes	2.33	1.62	3.43	0.39	(1.07)	1.73	0.43
Yams	2.72	0.00	0.92	(0.37)	0.72	5.40	2.06
Taro (cocoyam)	1.90	1.17	0.45	(1.90)	2.36	2.97	2.62
Sugar cane	3.70	2.96	1.25	3.32	(1.38)	(0.92)	(2.55)
Rice, paddy	(1.60)	1.48	0.93	(9.19)	(0.38)	1.73	(2.77)
Maize	11.41	4.17	2.94	3.26	(1.55)	0.41	5.48
Sweet potatoes	1.01	1.29	0.82	0.06	0.49	0.59	2.45
Potatoes	28.06	15.99	(4.87)	0.09	10.75	5.08	2.62
Fruits	1.62	1.74	1.27	2.70	2.98	2.34	1.55
Vegetables	2.78	2.64	2.63	2.79	3.04	1.49	0.60
Yield							
Coconuts	0.43	0.87	(1.83)	(0.66)	5.14	(0.23)	0.12
Oil palm fruit	0.00	(1.08)	(0.35)	2.38	(0.18)	(1.62)	(0.23)
Cassava	0.50	0.11	0.42	1.50	0.62	0.36	0.99
Roots and tubers, nes	(0.31)	(0.15)	(2.22)	0.06	2.90	0.08	(0.24)
Yams	(0.18)	1.44	0.28	(0.46)	1.03	(1.53)	0.29
Taro (cocoyam)	0.17	(0.36)	0.10	(1.30)	0.97	2.79	(0.83)
Sugar cane	8.12	3.35	4.06	(2.75)	2.61	(2.74)	(2.09)
Rice, paddy	0.19	2.91	0.71	(0.85)	7.34	(2.85)	0.10
Maize	11.38	7.51	0.62	12.69	5.94	(0.77)	(0.74)
Sweet potatoes	0.40	0.72	0.17	0.13	0.99	1.17	(0.06)
Potatoes	5.14	7.04	6.45	1.70	(0.98)	0.51	0.19
Fruits	0.88	0.21	0.65	(0.05)	(0.24)	(0.09)	0.88
Vegetables	0.55	0.00	0.02	(0.06)	0.44	0.17	(0.32)

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Appendix 1: Food Crops and Livestock Production, Pacific Region (*cont.*)

LIVESTOCK PRODUCTION							
	1960s	1970s	1980s	1990–1994	1995–1999	2000–2004	2005–2008
Production (tons)							
Beef and buffalo meat	6,572.89	11,102.8	15,201.9	17,223.6	17,344.6	16,994.6	16,767.5
Eggs primary	2,821.22	3,784.8	5,823.3	7,670.0	9,632.4	10,748.0	10,869.25
Milk, total	35,755.89	55,253.3	50,849.6	67,490.4	65,176.0	61,942.6	64,230.0
Poultry meat	2,341.33	3,958.3	8,545.7	12,483.2	15,982.6	18,339.0	22,068.25
Sheep and goat meat	510.22	408.9	691.2	775.4	1,020.6	1,117.0	1,086.75
Growth Rates (%)							
Beef and buffalo meat	9.43	3.31	2.42	0.28	0.45	(0.34)	(0.27)
Eggs primary	2.51	4.82	3.40	4.44	5.13	1.04	(0.46)
Milk, total	8.34	4.76	0.61	4.06	(2.91)	(1.43)	3.60
Poultry meat	3.20	8.53	6.17	7.19	1.41	6.13	2.06
Sheep and goat meat	0.62	(1.61)	6.53	2.99	4.35	6.16	(3.73)

ha = hectare, nes = not elsewhere specified or included.
Source: FAO Stat. www.faostat.fao.org (accessed 15 April 2010).

Appendix 2: Food and Livestock Production Performance in Pacific Countries

	Food Production Index (base 1999–2001)						Net per Capita Production Index (base 1999–2001)						Livestock Production Index (base 1999–2001)					
	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008	1960s	1970s	1980s	1990–1994	1995–1999	2000–2008
Cook Islands	164.2	191.7	150.2	100.2	96.4	68.9	135.0	152.0	133.2	89.0	90.4	74.6	32.1	51.3	68.9	51.8	91.6	80.6
Fiji	66.0	73.2	93.2	103.0	100.4	96.9	115.9	103.1	108.3	111.6	103.0	94.9	35.1	55.7	79.9	99.0	102.0	104.5
Kiribati	61.0	68.4	89.0	79.6	96.4	111.5	135.7	119.2	120.9	90.4	102.0	104.8	66.8	70.5	77.4	83.8	88.2	114.0
FSM	…	…	…	…	100.0	100.1	…	…	…	…	99.4	98.1	…	…	…	…	100.0	100.1
Nauru	58.1	70.3	87.8	97.4	99.6	100.9	105.1	102.3	107.4	101.8	99.6	100.6	34.6	49.3	73.2	95.2	99.6	100.3
Papua New Guinea	44.1	55.8	70.4	81.6	92.2	106.1	100.3	105.8	105.7	100.6	99.4	96.6	44.0	54.8	69.2	82.4	93.0	110.0
Samoa	91.6	101.4	117.6	84.4	97.6	104.0	128.4	120.6	133.0	91.6	100.8	101.3	42.2	48.1	77.0	94.0	93.2	104.3
Solomon Islands	41.8	55.7	80.1	83.6	99.8	107.4	127.4	122.2	126.0	104.4	108.2	97.8	37.7	73.8	88.6	88.2	92.6	108.5
Timor-Leste	61.6	74.7	79.6	111.4	106.8	111.8	83.0	90.8	97.9	106.8	101.4	93.8	86.8	79.3	59.8	108.4	113.8	121.1
Tonga	123.1	128.0	108.0	104.0	96.8	102.3	145.8	131.0	112.5	106.6	97.0	101.3	34.7	59.5	88.6	93.4	93.0	96.8
Tuvalu	97.0	80.1	92.5	96.0	92.0	107.4	143.9	103.9	108.9	97.6	92.0	105.9	23.0	24.9	39.1	71.6	89.6	104.0
Vanuatu	67.7	79.8	97.1	99.4	109.4	101.3	174.2	152.1	142.1	119.4	115.8	92.5	40.6	61.7	69.0	93.6	101.2	92.6

… = no data available, FSM = Federated States of Micronesia.
Source: FAO Stat. www.faostat.fao.org (accessed 15 April 2010).

Appendix 3a: Country-By-Country, Sector-Based Assessment of Adaptation Needs (Cook Islands, Fiji, Kiribati, Federated States of Micronesia, Papua New Guinea, Samoa, and Timor-Leste)

Climate Change Scenarios for the Year 2050						
	Cook Islands	**Fiji**	**Kiribati**	**FSM**	**PNG**	**Samoa**
Air temperature, °C (Sources: 1, 3, 4, 5, 7, 9, 10, 11)	HadCM2[a]: +1.2 CSIRO9M2[b]: +0.8	CSIRO9M2: +0.9 to +1.3 DKRZ[c]: +0.9 to +1.3	+1.2 to 5.6	Low = +0.4 Median = +0.8 High = +1.3	HadCM2: +1.2 CSIRO9M2: +1.3 Dec to Feb: +0.8 to 1.6 Jun to Aug: +0.75 to 1.75	+0.7
Annual rainfall (Sources: 1, 3, 6, 7, 9, 10)	HadCM2: +10.3% CSIRO9M2: –0.1%	CSIRO9M2: +5.7% to +8.2% DKRZ: –5.7% to –8.2%	+7% (+2 to +17) mm	An extreme rainfall event of 450 mm in the current climate with a return period of 118 years will shorten to 20 years by 2050, meaning more frequent high-intensity rain episodes	HadCM2: 2.2% CSIRO9M: 8.9% Dec to Feb: –5 to +4% Jun to Aug: –4 to +6%	1.2% An extreme 6-hour rainfall of 200 mm, currently a 30-year event, will likely become a 20-year event
Sea level/sea level extremes (Sources: 1, 3, 4, 5, 6, 7, 10)	Best guess: 20 cm High estimate: 40 cm	Best guess: 23cm High estimate: 43 cm Best estimate for Nadi is 20 cm For Nadi and Lautoka: A high sea level that is a 100-year event will become a 20-year event in 2050	2050s: 0.25 to 0.36 m 2090s: 0.48 to 0.79 m King tides: Currently 15% of all high tides 2090s: 29% to 76% of all high tides (possibly 96%)	At Pohnpei and Kosrae: High: +40 cm Best:: +20 cm Low: +8 cm For Pohnpei: Return period of an observed hourly extreme sea level of at least 1 m: Current = 4 years By 2025 = 2 years By 2050 = 1 year	Best guess: 20 cm High estimate: 40 cm	Best guess: 36 cm The observed long-term trend in relative sea level: Local mean = 5.2 mm/yr At Apia = 8 mm/yr Return period of an hourly sea level of 1.8 m above mean sea level: Current = 1 in 100 years In 2025 = 1 in 4 years
Weather extremes (Sources: 2, 4, 6, 7, 9, 10)	Rainfall might be characterized by high-intensity events on the one hand and prolonged droughts on the other. For Rarotonga: A rare event of daily total rainfall above 200 mm has a return period of 11 years	At Nadi: Wind gust >60 knots. Increase in frequency and/or magnitude of tropical cyclones	Tarawa daily rainfall (100 year event): Current = 304 mm 2025 = 306–345 mm 2050 = 317–370 mm 2090 = 330–424 mm	More frequent high-intensity rain episodes	Droughts and floods effects intensified	At Apia: Wind gusts: + 7%. Current extreme wind gust of 70 knots with a return period of 75 years will reduce to about 40 years by 2050

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Appendix 3a: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050						
	Cook Islands	**Fiji**	**Kiribati**	**FSM**	**PNG**	**Samoa**
Climate extremes (Sources: 2, 4, 6, 7, 9, 10)	Trend: A possible consequence of the increased persistence of El Niño conditions in recent decades is the apparent intensification of tropical cyclones	More El Niño like conditions; increase in drought events	More El Niño like state; drought characteristics similar to current conditions, but may be more prevalent for the next 100 years	ENSO is the dominant influence on climate. In general, a more El Niño like mean state over the Pacific under climate change	Greater ENSO influence on extremes	No definite signal
Agricultural production and food security	Sea-level rise and saltwater inundation into the underground fresh water lens will impede crop growth in low-lying northern group of atolls Loss of land will reduce available land for agricultural production Lack of rain, shifting seasons, and soil degradation reduce productivity Increased forest fires	Reductions in production of 30%–40%	Reduction in agricultural productivity, starting first with less resilient crops and ultimately affecting coconut Diminishing fish stocks due to coastal erosion, higher sea surface temperature, and sea-level rise	Loss of land due to inundation	Reduced agricultural production due to the following: • Rapid postharvest deterioration of crops • Greater rate of water loss through evaporation • Soil degradation • Humid conditions will favor increased incubation of pests and diseases • Shorter time for crops to mature	Instability of food production levels to meet higher demand
Coastal sector/tourism industry	Increased ocean acidification will deteriorate marine resources for tourist attractions (e.g., corals) Low agriculture outputs will increase imports (e.g., fresh vegetables) to meet demands of tourist industry	Loss of tourist attractions Coral bleaching Increase in shoreline and beach erosion	Coastal land erosion becomes more extensive, intensive, and persistent Erosion threatens existing roads and buildings			Loss of beaches, inundation and degradation of the coastal ecosystems, saline intrusion, damage to critical infrastructure, and the loss of attractiveness of corals due to bleaching
Water	Long dry periods will reduce water supplies to critical levels Higher volcanic southern islands as a result of sea level rise will experience saltwater inundation in ground/freshwater lens and the infrastructure surrounding the coastal areas of the islands will be at risk	Reduced water availability	Ground water lens turning more brackish Soil degradation	Salinization of freshwater lenses	Loss of freshwater due to saltwater intrusion	Water quality and availability of water directly impacts the livelihoods of the communities Sea-level rise increases the possibilities of seawater intrusion into underground water aquifers, as already experienced by many coastal communities

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Appendix 3a: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050						
	Cook Islands	**Fiji**	**Kiribati**	**FSM**	**PNG**	**Samoa**
Agriculture/ agroforestry		Research into more flexible farming systems that are tolerant to climatic variability Development of sustainable production systems such as agricultural diversification schemes		Encourage farmers to improve farming practices to suit changing climate Ensure an appropriate upland watershed protection program component is integrated into any nationwide community-based coral reef protection program and coastal zone management Establish marine protected areas that provide for the customary harvesting of reef resources by Micronesians using traditional collection methods		Marketing and trading Alternative crop research Early warning systems Traditional planting rescheduling
Capacity building	Develop guidelines to integrate climate change into sector and sustainable development plans Access to national and international technical expertise and appropriate technology transfer Continue to address major gaps in planning and policy, regulations, and legislation Continued lobbying for mitigation and adaptation assistance Training and incentives for private sector driven adaptation such as in the construction industry				Building capacity in provincial and national government agencies to implement laws and plans Maintain gene pools through a system of connected protected areas Improve resource information Comprehensive disaster management programs	

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Blank cells = no information, CRP = climate risk profile, ENSO = El Niño Southern Oscillation, FSM = Federated States of Micronesia, mm = millimeter, PNG = Papua New Guinea.
Note: Climate risk profiles were prepared by the ADB Pacific Department to provide information on historical trends and possible future ranges of different climatic variables (temperature, rainfall, and sea-level rise) for 10 Pacific developing member countries. Six of these were completed as technical reports (Cook Islands, Kiribati, the Marshall Islands, the FSM, and Samoa. The other four (Palau, Tonga, Tuvalu, and Vanuatu) are still in draft form.
A return period also known as a recurrence interval is an estimate of the interval of time between events like an earthquake, flood, or river discharge flow of a certain intensity or size. It is a statistical measurement denoting the average recurrence interval over an extended period of time, and is usually required for risk analysis (i.e., whether a project should be allowed to go forward in a zone of a certain risk) and also to dimension structures so that they are capable of withstanding an event of a certain return period (with its associated intensity). Source: http://en.wikipedia.org/wiki/Return_period
a HadCM2 is the coupled global climate model developed at the Hadley Centre, Bracknell, United Kingdom.
b CSIRO9M2 is the nine-layer global circulation model of Australia's Commonwealth Scientific and Industrial Research Organization.
c DKRZ = German Climate Computation Center, Hamburg.
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Appendix 3b: Country-By-Country, Sector-Based Assessment of Adaptation Needs (Marshall Islands, Nauru, Palau, Solomon Islands, Tonga, Tuvalu, and Vanuatu)

Climate Change Scenarios for the Year 2050							
	Marshall Islands	**Nauru**	**Palau**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Air temperature, °C (Sources: 1, 2, 3, 4, 7, 8, 9, 10, 12)	CSIRO9M2[a] Mid: 0.9 High: 1.4 HadCM2[b] Mid: 1.3 High: 2.1	CSIRO9M2: +0.9 HadCM2: +1.5	Dec–Feb: +0.80 to +1.60 Jun–Aug: +0.75 to +1.75	BMRC[c]: 0.7 CSIRO9M: 0.8 ECHAM3TR[d]: 1.1	Max air temp: 1.2 Max water temp: 0.2	Best estimates BMRC: 0.7 UKHI[e]: 0.5 CSIRO9M2: 0.9 HadCM2: 1.4	Max air temp: 0.2 Max water temp: 0.19 Increased occurrences of extreme high sea levels and air and water temperatures
Annual rainfall, % (Sources: 3, 4, 7, 8, 9, 10)		CSIRO9M2: +10.9 HadCM2: +2.4		BMRC: -0.4 to +1.0 CSIRO9M2: +2.0 to +2.5 ECHAM3TR: +3.7 to +4.5	Best estimates, using MAGICC ScenGen[j] HadCM2: -9.8 ECHAM4[f]: +3.4 CSIRO2EQ[g]: +4.8 GFDLTR[h]: +3.8 CCCM1-TR[i]: –3.8	Best estimates: BMRC: –0.4 UKHI: –27.9 CSIRO9M2: 1.6 HadCM2: 6.3	Best estimate: +0.6
Rainfall extremes (Sources: 1, 2, 3, 6, 9, 10, 12)	Canadian GCM[j], with A2 emission scenarios: Increased frequency of months with extreme low rainfall and associated drought	Uncertain about future extremes. Current observations, though, suggest ENSO[k] affects rainfall and sea level significantly	Dec toFeb: –5 to +4% Jun to Aug: –4 to +6%		Both high and low (extremes) rainfall projections, higher probabilities of dry periods	By analogy: ENSO events have been experienced in Tuvalu with greater frequency over the last 2 decades; it is expected to become more frequent with climate change	Less certainty regarding changes in the frequency of intense daily rainfall events, but indications that frequency of these events will increase in the future

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Appendix 3b: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050							
	Marshall Islands	**Nauru**	**Palau**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Drought (Sources: 2, 6, 7, 9, 12)	Increase in severe droughts, especially in the northern atolls		In Koror: Increased return period of extreme hourly/ daily rainfall. An hourly rainfall of at least 120 mm is currently a 120-year event. By 2050, it is projected to be an 80-year event. A daily rainfall of at least 400 mm is currently a 155-year event. It will likely be a 100-year event by 2050.		Decreased rainfall Periods of low rainfall are prolonged dry periods	By analogy: El Niño events bring warmer, wet conditions, whereas La Niña conditions are cooler and drier drought conditions	
Extreme winds (Sources: 1, 6, 7, 10)	A peak gust of about 35 knots, considered a rare event in the current climate, has a return period of 21 years; by 2050 the return period will be 1:11, or about twice as often				Extreme wind gusts: 7% A current 100-year event of a maximum daily wind gust of 65 meters/second is likely to be a 50-year event by 2050	By analogy: Tropical cyclones appear to have increased in frequency in Tuvalu. The most recent severe events was cyclone Percy (March, 2005) which had significant effects in Tuvalu	Extreme wind gusts: 6.8% Increased occurrences of damaging winds are highly likely in the coming decades
Sea level/sea level extremes (Sources: 1, 2, 3, 4, 6, 9, 10, 12)	Mid: 19.9 cm High: 39.7cm At Majuro: Extreme high sea levels Hourly mean: 3.05 cm/decade Daily mean: 2.54 cm/decade An hourly sea level of 1.2 m above mean sea level is a relatively rare event, with a return period of 6 years. By 2050, this event will be at least once a year	Mid: 20 cm High: 40 cm	Current observed long-term trend in extreme high sea levels: Local mean: 0.7 mm/year At Malakal: 2.5 mm/year Return period of at least 3.0 m above mean sea level Current = 270-year event 2050 = 20-year event	Mid: 20 cm High: 49 cm	Best estimate: 36 cm Current observed long-term trend in extreme high sea levels: Local mean: 8.5 mm/year At Nuku'alof: 0.7 mm/year Return period of at least 2.2 m hourly sea level Current = 580-year event 2050 = 1.5-year event	Current observed long-term trend in extreme high sea levels: Local mean: 5.2 mm/year At Funafuti: 8.0 mm/year Return period of at least 3.7 m hourly sea level Current: = 445-year event 2050 = 5-year event	Best estimate: 20 cm Current observed long-term trend in extreme high sea levels: Local mean: 5.5 mm/year At Port Vila: 1.9 mm/year Return period of at least 1.9 m above mean sea level Current = 136-year event 2050 = 3.6-year event

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Appendix 3b: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050							
	Marshall Islands	**Nauru**	**Palau**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Agricultural production and food security	Reduced productivity resulting from land loss due to inundation and prolonged periods of drought		Substantial agricultural losses (50%) due to extreme climate events	Lower crop yields due to: Increase in frequency or intensity of extremes Loss of land through sea-level rise and reduced land quality through erosion Rapid impacts of extreme events (cyclones, floods) Delayed impacts (stress and shock to crops caused by soil leaching, erosion, and changes in pests and diseases due to effects of temperature changes, saltwater intrusion, storm surges, droughts, floods, prolonged heavy rain, prolonged cloud cover)	Reduction of crop yields Threat to food security (e.g., increasing soil salinity)	Decreasing agricultural yields due to increasing salinity of groundwater	Changes may be detrimental to agricultural production and hence national food security

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Appendix 3b: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050							
	Marshall Islands	**Nauru**	**Palau**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Coastal resources and tourism	Inundation and flooding of low-lying areas Coastal erosion Possible increase in cyclone-related effects Changes in sediment production due to changes in coral reef systems Coral bleaching and coral degradation Changes in mangrove health and distribution Degradation of sea grass meadows	Coastal erosion, decline in health of the reef system and other ecosystems (e.g., sea grasses and mangroves) Increased flooding and overtopping during storms Salinization and decreased recharge of groundwater	Coral bleaching Threat to coral reef system and to the human populations that depend on them. (By analogy: During the 1998 El Niño, a massive coral bleaching killed one-third of Palau's coral reef, causing annual tourism revenues to drop by 9% and the local economy to lose an estimated $91 million) Ocean acidity increases the risks of coral degradation	Increase in coastal flooding and inundation Increased coastal erosion Negative impact on coastal ecosystems from sea-level rise Changes in abundance of migratory species and health of corals, including bleaching and damage from cyclones Sediment loads in lagoons and inshore waters Specific impacts on each destination and activity due to cyclones, storm surges, droughts, flooding, fires, vector-borne diseases, and aquatic infections	Destruction of habitats of some marine species Reduction in diversity of marine species in coral reefs Threat to the survival of ecotourism and fishery sectors Land loss due to greater exposure of the shoreline to wave action		Flooding and inundation may have negative economic impacts, as national investments in infrastructure and agriculture are primarily in low-lying coastal areas around the perimeter of the major islands Decreased suitability of conditions for survival of corals, mangroves, and other coastal ecosystems

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Appendix 3b: Country-By-Country, Sector-Based Assessment of Adaptation Needs (*cont.*)

Climate Change Scenarios for the Year 2050							
	Marshall Islands	**Nauru**	**Palau**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Water sector	Changes in freshwater lenses and other groundwater resources Salt intrusion of groundwater resources Changes in surface water resources Changes in surface runoff, flooding, and erosion Increased rainwater harvesting at household and community levels		Saltwater intrusion into groundwater Intense droughts and storms leading to land degradation in the watershed	Rising sea levels and coastal erosion resulting in damage to water infrastructure as well as saltwater intrusion into groundwater lens	Prolonged dry periods will decrease water supply for uses in rural areas and outer islands Reduction in recharge to groundwater means reduction in potable water supply for uses in rural areas and outer islands	Increasing frequency of drought and longer periods of low rainfall increases salinity of groundwater The quality and availability of potable water poses challenges with respect to impacts of climate change and sea-level rise	Possible reduction in the rate of groundwater recharge and surface water flows More pronounced periods of water shortages Increased turbidity in surface waters causing decreased suitability for domestic uses Saltwater intrusion into the shallow groundwater lens in coastal areas
Agriculture				Improved agricultural practices (e.g., diversification, soil and water conser-vation) and use of technology Protection of mangrove and coral reef systems Improved water management, supply, distribution, and storage			Expansion of the range of agricultural products Selection of plant varieties better suited to predicted future climates Capacity building (particularly for science-based knowledge) and public awareness

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a CSIRO9M2 is the 9-Layer Global Circulation Model of Australia's Commonwealth Scientific and Industrial Research Organization.
b HadCM2 = coupled global climate model developed at the Hadley Centre, Bracknell, United Kingdom.
c BMRC = Australian Bureau of Meteorology Research Center.
d ECHAM3T = a climate model from the European Centre Medium-Range Weather Forecast with increased resolution simulations.
e UKHI = United Kingdom Meteorological Office High Resolution Model.
f ECHAM4 = a climate model from European Centre for Medium-Range Weather Forecasts with a fully coupled sulfur chemistry–cloud scheme.
gCSIRO2EQ = a global circulation model developed by Australia's Commonwealth Scientific and Industrial Research Organization.
h GFDLTR = a coupled ocean atmosphere land surface model from Geophysical Fluid Dynamic Laboratory with transient responses to a gradual change of atmospheric carbon dioxide.
i CCCM1-TR = Canadian Climate Centre for Modelling and Analysis 1–Transient.
j GCM = global climate model.
k ENSO = El Niño Southern Oscillation.
l MAGICC ScenGen = Model for the Assessment of the Greenhouse Gas Induced Climate Change, a regional climate scenario generator.
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Appendix 4: Synergy between ADB Assistance and 2010 Framework for Action on Food Security in the Pacific[a]

Framework Theme	Expected Outcome	ADB Strategy Area and Possible Interventions
1. Leadership and cooperation	Strong leadership and effective multisectoral coordination for food security regionally and nationally	Capacity development • Convene regional or bilateral meetings to consider merits of establishing well-compensated government teams on climate change and food security • Convene regional meeting on cooperation on food security under climate change; intraregional trade policies • Convene regional policy workshop(s) on the role of Pacific urbanization in food security and climate change Potential investments • Subsequent loans for outcomes on infrastructure, transport, etc.
2. Regulatory frameworks, enforcement, and compliance and public-private sector collaboration	Strengthened food regulatory frameworks, enforcement, and compliance capacities and public-private sector collaboration	Capacity development • Convene regional meetings on regulatory frameworks and public-private sector collaboration • Technical assistance (TA) for training of trainers for enforcement officers and for private sector and government officials on compliance • TA support for improving and enforcing management regulations in coastal fisheries • TA support for development of regional food standards • TA on strengthening biosecurity, disease surveillance, and emergency response capacity to protect plant, animal, and human health • Workshops on commodities based on introduced species that promise to help provide food security in order to reconcile the issues of biodiversity and food security
3. Enhanced and sustainable production, processing, marketing, trading, and use of safe and nutritious local food	Improved production, processing, marketing, trading, and use of safe and nutritious local food	Capacity development • Convene regional meetings to formulate plans for improved production, processing, storage, distribution of local produce, subregional storage facilities, water management plans • TA for workshops on nutrition, ways to counter imported-food-is-better/modern syndrome, cost benefits associated with offshore fisheries and reallocation to domestic consumption • TA to develop local fishery methods for offshore stocks (e.g., fish aggregation devices) • TA to help develop new technologies for small farmers improve their traditional skills under changing climate conditions • TA support for research and development to improve livestock production systems adapted to climate change • TA support for networking research and development institutions for economies of scale • TA to support assessing the future of freshwater aquaculture to enhance fish protein supplies • TA to investigate export (regional and overseas) markets for agricultural produce Potential investments • Loans for outcomes on agriculture research and development facilities, emergency storage facilities, etc., infrastructure, and food-testing laboratories • TA and loans for planning and implementing regional and in-country fish distribution mechanisms

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Appendix 4: Synergy Between ADB Assistance and 2010 Framework for Action on Food Security in the Pacific[a] (*cont.*)

Framework Theme	Expected Outcome	ADB Strategy Area and Possible Interventions
4. Protect infants and vulnerable groups	Increased well-being, reduced illnesses, disabilities, and premature deaths associated with a lack of food security	Capacity development • Convene workshops on protection for vulnerable groups—safety nets, education, awareness programs, nutrition studies • TA to promote related activities (e.g., mapping vulnerable groups, improved lifestyles, breastfeeding, social protection, strategies to address rapid population growth) • TA and possibly loans to investigate the need for and implementation of fortification of local foods with essential micronutrients
5. Consumer empowerment and mobilizing partners	Individuals, communities, producers, and governments empowered with information about food security and the skills to make informed decisions and healthy choices	Capacity development • Convene regional meetings on empowering consumers Potential investments • Support for development of education, communication, and advocacy agenda on food security • Include food security as part of regional climate change financing facility
6. Food security information system	A comprehensive food security intelligence capacity established to document progress, identify vulnerabilities, spread innovation and provide evidence for appropriate implementation of programs	Capacity development • Convene regional meeting on food security information system (e.g., gaps, indicators, data sources) • TA on implementation, training • TA support for assessment of different food security interventions Potential investments • TA to develop regional hub and satellite facilities
7. Enhanced land tenure systems and land use policies, energy, transport, education, and communication systems to underpin food security	Effective land use, energy, transport, communication, and education support to food security	Capacity development • Regional meeting on cross-cutting issues that affect food security • TA for country-led initiatives that enhance land tenure systems and land use policies • TA support to strengthen policy, legal, and legislative frameworks to improve transport • TA to promote restoration of coastal forests and sustainable use of forest food resources Potential investments • Subsequent loans for these activities.

TA = technical assistance.

a Secretariat of the Pacific Community. 2010. *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific*. www.foodsecurepacific.org/documents/FINAL%20TOWARDS%20A%20FOOD%20SECURE%20PACIFIC_June1.pdf

Appendix 5: ADB's Pacific Climate Change–Related Portfolio: Selected Ongoing and Pipeline Projects Addressing Climate Change in the Pacific Region

In the highly vulnerable and already hard-hit Pacific region, responses to the impacts of climate change will be more effective through a concerted and coordinated response, based on a comprehensive understanding of the countries' needs and capacities. The Pacific island governments view climate change as a priority issue, but need clear objectives in addressing its impacts. ADB is in a position to analyze the complex problems at all levels; identify appropriate solutions based on the varied geographic, social, and environmental conditions; and mobilize technical and financial assistance to implement solutions in a holistic manner. ADB has already begun to mainstream climate change activities into its operations and will continue to identify and implement appropriate solutions-based interventions.

Past and Ongoing Initiatives

Since the first regional climate change adaptation project, *TA 6064-REG: Climate Adaptation Program for the Pacific (CLIMAP)*, was implemented in the Cook Islands and the Federated States of Micronesia (FSM) in 2003–2005, ADB has supported the climate change response of its Pacific developing member countries (DMCs) through these initiatives:

- systematic incorporation of adaptation issues into the ADB Pacific Department portfolio starting in 2005;
- mainstreaming of climate change adaptation and mitigation in country partnership strategies (covering 5-year periods between 2007 and 2014) with the Cook Islands, Kiribati, Palau, Papua New Guinea (PNG), Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu to ensure that climate change implications are incorporated in economic development policies and planning processes;
- conduct of climate risk studies in 10 Pacific DMCs (the Cook Islands, Fiji, the FSM, Kiribati, the Marshall Islands, Palau, Samoa, Tonga, Tuvalu, and Vanuatu) and preparation of their climate risk profiles, which could serve as bases for climate change adaptation initiatives for various development sectors;
- incorporation of climate change adaptation in infrastructure projects, such as the Avatiu Harbor Development Project in the Cook Islands, the Highland Region Road Improvement Program in PNG, and the Road Network Development Sector Project in Timor-Leste; and
- preparation of climate change adaptation briefs for planned projects.

In 2007, the Pacific island governments adopted an action plan to carry out the Pacific Islands Framework for Action on Climate Change, in which national activities are complemented by regional programming. Development partners have been providing advice and support for adaptation and mitigation efforts for several years. Toward this end, the following ADB projects incorporated climate change adaptation and/or mitigation in their design:

- *TA 6420-REG: Promoting Climate Change Adaptation in Asia and the Pacific (2007–2009)*, which was designed to help address the need to (i) mainstream adaptation issues into investment planning; (ii) develop national capacity for adaptation; (iii) coordinate and strengthen international community responses for adaptation; and (iv) support participating governments in adopting investment programs, plans, policies, and other actions to adapt development to expected future climatic conditions;
- *Grant 0078-SOL: Emergency Assistance Project, Solomon Islands (2007–2009)*, which assisted the government in rehabilitating damaged infrastructure and making it less vulnerable to climate change and natural hazards;
- *TA 4944-SOL: Strengthening Disaster Recovery Planning and Coordination (2007–2009)*, piggybacked on Grant 0078-SOL, which was aimed at strengthening disaster management, infrastructure planning, and capacity to ensure that infrastructure designs incorporate adaptation and mitigation strategies and are less vulnerable to climate change and potential future disasters;

- *TA 6471-REG: Strengthening Coastal and Marine Resources in the Coral Triangle of the Pacific (Phase 1)* (2009) (Fiji, PNG, Solomon Islands, Timor-Leste, and Vanuatu), under which a project was designed to ensure the conservation and sustainable management of coral reef ecosystems and coastal and marine biological resources and include adaptation measures for integrated watershed and coastal management, including marine protected areas;
- *REG 4187-01: Regional Partnerships for Climate Change Adaptation and Disaster Preparedness* (2009–2010) (the Cook Islands, Fiji, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu), which compiled and consolidated data on the country's exposure to hazard risk in a geographic information system platform;
- *TA 7394-REG: Strengthening the Capacity of Pacific Developing Member Countries to Respond to Climate Change (Phase 1)* (2009–2011), under which the Pacific Climate Change Program was established, mainly to ensure the continued economic growth of Pacific DMCs by reducing their vulnerability to the risks and impacts of global climate change;
- *Grant 0175-SOL: Second Road Improvement Sector Project* (2009–2015), which includes climate adaptation strategies and features in the design of roads for rehabilitation and construction;
- *Grant 0180-TIM: Road Network Development Sector Project* (2009–2015), which incorporates climate change adaptation into the design and implementation of the road civil works to help avoid losses due to climate change;
- *Loan 2713/2714-PNG: Town Electrification Investment Project* (2010–2014), which will consider greenhouse gas mitigation and climate proofing in the establishment of rural electrification facilities that will expand current service coverage area; and
- *TA 7753-REG: Strengthening Coastal and Marine Resources in the Coral Triangle of the Pacific (Phase 2)* (2010–2014) (Fiji, PNG, Solomon Islands, Timor-Leste, and Vanuatu), which will help ensure food security for the Pacific Coral Triangle Initiative countries as a result of the increased resilience of coastal and marine ecosystems achieved through more effective coastal and marine ecosystem and resources management.

Several ADB Pacific Department initiatives aimed at climate mitigation, or that have mitigation elements, have been conducted or approved for future implementation, primarily in the energy sector. These projects, which are generally aimed at promoting sector reform, efficiency improvement, and renewable energy development, include the following:

- *ADTA 4932-PNG: Power Sector Development Project* (2007–2009), intended to assist the PNG government in examining issues and options to promote and facilitate the provision of reliable, safe, and affordable access to an efficient power supply;
- *RETA for Promoting Energy Efficiency in the Pacific* (2008–2009) (the Cook Islands, PNG, Samoa, Tonga, and Vanuatu), aimed at helping improve energy security in the participating Pacific DMCs and developing sound models of energy efficiency policy and project implementation that all the Pacific island countries can follow;
- *Implementing the National Energy Policy, Samoa* (2008–2015), piggybacked on the Advisory TA 4932-PNG: Power Sector Development Project to promote the development of clean energy resources through the establishment of a clean energy fund; enable Samoa to participate in carbon market trading; and develop the required policy, legal, and institutional frameworks for energy efficiency projects, among others;
- *TA 7121-SAM: Preparing the Afulilo Environmental Enhancement Project* (2010), in which a project was designed to enhance the sustainability of the existing Afulilo Hydropower Project and conduct due diligence for project processing and preparation for project implementation, including assessment of eligibility for Clean Development Mechanism (CDM) and preparation of CDM project design documents;
- *Cluster Renewable Energy and Environmental Project–Subproject 2, Marshall Islands* (2011), which will assist the government's reforms to improve the efficiency and capacity of infrastructure services and increase access to services in the power, water and sanitation, and telecommunication sectors;

- *TA 7394-REG: Strengthening the Capacity of Pacific Developing Member Countries to Respond to Climate Change (Phase 1)* (2009–2011), which will assist Pacific DMCs in addressing climate change impacts by building resilience through adaptation to climate change, climate variability, and extreme weather events—taking into account country-specific issues and needs at the local level; and
- *TA 7827-REG: Strengthening Climate Risk and Resilience Capacity of Pacific Developing Member Countries, Phase 1* (2011–2012), which will concentrate on climate-resilient infrastructure development planning, budgeting, and implementation by the PNG and Tonga governments and on developing strategic programs for climate change resilience for 2011–2015 for investments in PNG and Tonga.

Projects in the Pipeline

ADB's Pacific Department will continue to work within the overall framework of Strategy 2020 and the *Pacific Approach 2010–2014*, under which new activities including adaptation will be formulated, taking into account the envelope of internal resources, availability of cofinancing, and absorptive capacity of Pacific DMCs. To support its commitment to addressing climate change in its Pacific DMCs, ADB has set a target of directing 40% of investment resources toward environment and climate change by 2020.

The following technical assistance and loan projects, included in the ADB Pacific Department's 2010–2013 Work Plan, are anticipated to require climate adaptation inputs, particularly those in the infrastructure (water supply and sanitation, hydropower); transport (road, water, air); and energy sectors:

- Technical assistance projects for processing:
  - Cook Islands: Improving the Delivery of Infrastructure Services, Phase II
  - Palau: Water Supply and Sanitation Strengthening Project
  - PNG: Infrastructure Sector Development Implementation Support
  - PNG: Bridge Replacement for Improved Rural Access Project
  - Timor-Leste: Rural Town Water Supply Design
  - Timor-Leste: Water for Livelihood and Poverty Reduction
  - TON: Integrated Urban Development Project, Phase II
  - Regional: Promoting Energy Efficiency in the Pacific, Phase II
  - Regional: Support to Development of Clean Energy
- Loans for processing:
  - KIR: South Tarawa Sanitation Improvement Project
  - PAL: Koror-Airai Sanitation Project
  - PNG: Strengthening Rural Primary Health Services Delivery Sector Project
  - PNG: Second Community Water Transport Sector Project
  - SAM: Water Supply, Sanitation, and Drainage Project, Phase II
  - SAM: Power Sector Expansion Project, Phase II
  - VAN: Port Vila Urban Development Project
  - VAN: Interisland Shipping Support Project
  - Regional: Regional ICT Connectivity Project

ADB acknowledges that continued poverty reduction will not be possible without proactive efforts to address environmental sustainability, including mitigating the causes of global warming and helping the most vulnerable citizens adapt to the already unavoidable impacts of climate change. The climate change agenda has become one of the defining challenges that ADB—and the entire development community—must face in achieving further progress in poverty reduction and food security in the Pacific and beyond.

Table A5: Examples of Specific Country-Level Needs for Mitigation and Adaptation, Including Synergies

Country	Mitigation	Adaptation	Synergies[a]
Cook Islands	Reduced greenhouse gas emissions through improved energy efficiency and conservation	Strengthen resilience of coastal communities and infrastructure; increase capacity to respond	Strengthened approaches to integrated environmental quality monitoring and assessment
Fiji	Improved efficiency of energy consumption in the transport sector; improved awareness of the government and civil society of the benefits of energy-efficient transport systems	Increase long-term sustainability of tourism development, including reduced vulnerability of the tourism sector to climate change	Preservation of island biodiversity
Kiribati	Reduced greenhouse gas emissions through use of clean renewable energy	Improve causeways and coastal protection	Promoting planting of atoll food crops, including indigenous and introduced food crops
Marshall Islands	Promotion of a coordinated approach to financing renewable energy by donors and financiers	Increase resiliency and preparedness for natural disasters to reduce the potential for large-scale economic costs to communities and the country	Increased capacity for land management and land use schemes for the development of agroforestry
Micronesia, Federated States of	Enhanced carbon sequestering through improved capacities for sustainable forest management, sustainable agriculture, and reduced deforestation	Increase resiliency of basic infrastructure against natural disasters and other trends related to climate change	Strengthened information management systems on integrated land use planning and sustainable land management to support decision making at national and state levels
Nauru	Reduced emissions from power generation, a defined baseline for mitigation projects, introduction and use of solar thermal energy for water heating and solar photovoltaic energy for lighting	Revise the Rehabilitation Master Land Use Plan and the National Environmental Action Plan to take into account the possible effects of climate and sea-level change on the proposed activities, and identify needed modifications to accommodate adaptation	Reduced amount of waste going to landfills; this will help decrease impacts on natural ecosystems
Palau	Improved local expertise and skills to monitor and analyze renewable energy resources measurements and data; planning, design, monitoring, and maintenance of renewable energy installations	Inventory existing resources to assess vulnerability/resistance, develop mitigation/evacuation strategies for the most vulnerable and protection strategies for the most resilient areas, strengthen capacity of institutions for disaster management preparedness and response	Strengthened institutional mechanisms and capacity for equitable and integrated land use planning and sustainable land management to improve harmonization and implementation at the national, state, and local levels
Papua New Guinea	Widespread application of biomass-based energy systems	Protect public coastal assets and infrastructure	Development of an effective enabling environment for mainstreaming environment issues into forest use decision making processes

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Country	Mitigation	Adaptation	Synergies[a]
Samoa	Development of biofuel as an alternative to fossil fuel, improved building design and construction to reduce energy use	Enhance food security, strengthen resilience of coastal communities, protect coastal wetlands	Sustainable development of forest resources among rural communities, improved support for rural livelihoods from forest products
Solomon Islands	Increased reforestation and use of biomass energy	Engineer and construct climate-proofed wharves to cope with a 60-year storm, implement integrated coastal management; improve resilience of intra- and interisland transportation	Better understanding of the state of the environment, sustainable use of natural resources, more informed local communities
Timor-Leste	Prevention of land degradation through integrated policies and development of alternative energy sources and improved agricultural practices for forest-reliant poor	Draft climate change-related policy and legislation based on outcomes of national adaptation plan of action	Increased capacities to formulate integrated national legislation on environmental management, collect soil data, and implement risk assessment methodology
Tonga	Improved energy efficiency of existing buildings, energy efficiency compliance of new buildings	Integrate coastal zone management plan, enhance coastal protection systems; strengthen legislation to regulate onshore and offshore sand mining	Economic valuation of Tonga's biodiversity and the associated ecosystem services
Tuvalu	Solar photovoltaic systems for seven outer islands to improve livelihoods of outer island communities and reduce greenhouse gas emissions	Increase resilience of coastal areas and settlements to climate change	Strengthened environmental governance and improved land use planning and resource management to safeguard the long-term sustainability of the natural resource base and improve social and economic opportunities
Vanuatu	Improved energy efficiency through use of renewable sources, improved energy efficiency of motorized transport; increased levels of nonmotorized transport, improved understanding of ethanol as a biofuel	Enhance early warning systems, improve management of climate health relationships, improve food security, improve resilience of coastal communities	Coherent institutional framework and national institutions capable of coordinating responses to national and global environmental concerns

a The synergies listed here are actions that deliver both adaptation and mitigation outcomes. They do not necessarily involve the same activities and outcomes listed separately under adaptation and mitigation.

Source: ADB. 2009c. *Mainstreaming Climate Change in ADB Operations—Climate Change Implementation Plan for the Pacific*. Manila.

Food Security and Climate Change in the Pacific
Rethinking the Options

The Pacific developing member countries (DMCs) of the Asian Development Bank (ADB) are a diverse array of countries with widely varying topographies, cultures and economies, fragile natural resource environments, and prosperity, stability, and security that can be compromised by the impacts and consequences of climate change. The Pacific island governments view climate change as a priority issue, especially in terms of its potential impacts on food security, and need clear directions in addressing both issues. This report describes the present state of food security and its contributing factors in the Pacific region, assesses its prospects amid the growing threats and likely impacts of climate change, and presents potential areas for more active assistance, investments, and interventions from ADB and other development partners. While technical and policy measures to ensure food security amid the ensuing climate change are numerous, interrelated, and complex, the successful implementation of programs and projects calls for simple and flexible designs that carefully consider the capabilities of relevant stakeholders at the regional, national, and local levels.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to two-thirds of the world's poor: 1.8 billion people who live on less than $2 a day, with 903 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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