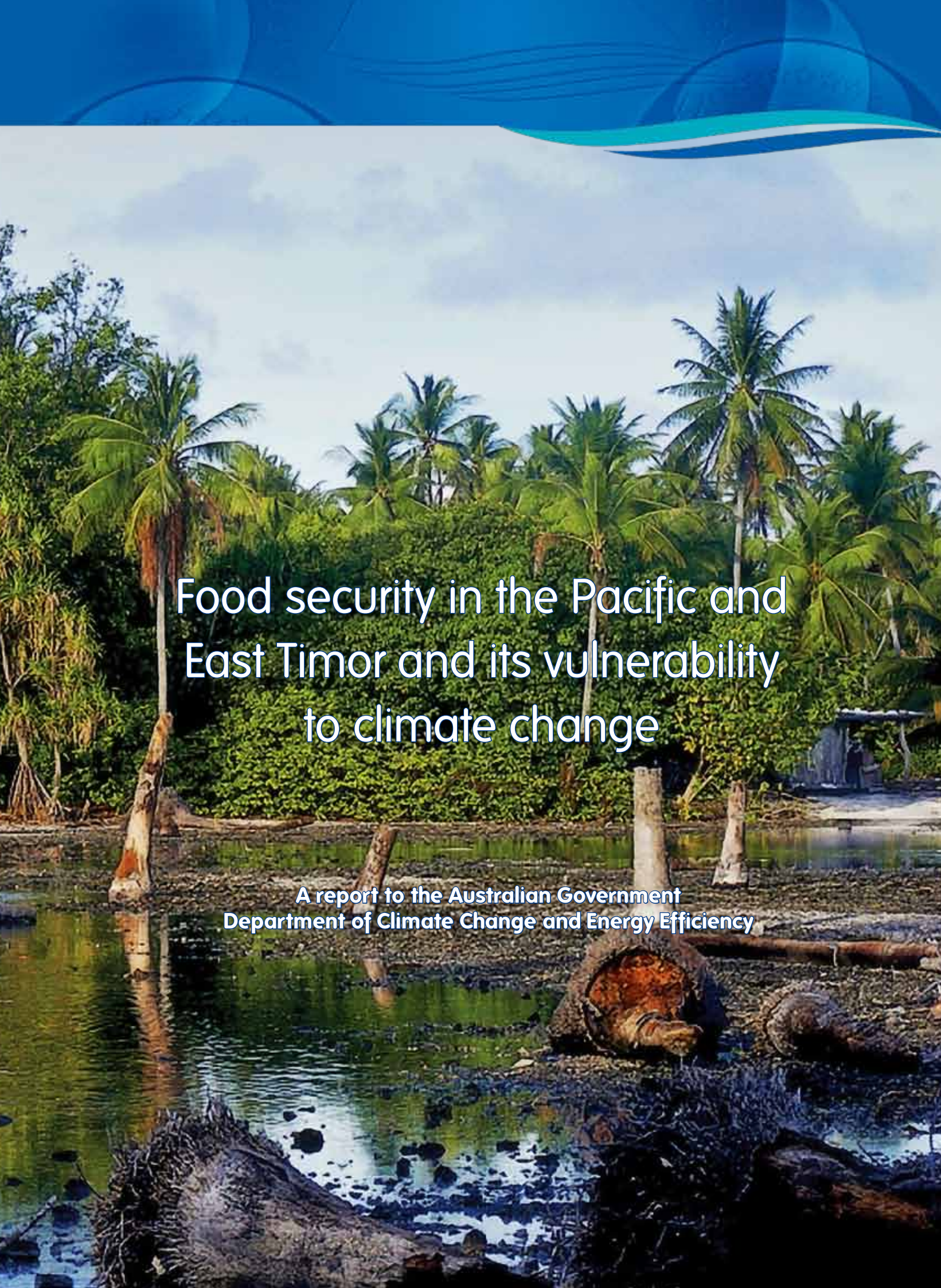

Food security in the Pacific and East Timor and its vulnerability to climate change

A report to the Australian Government
Department of Climate Change and Energy Efficiency

Food security in the Pacific and East Timor and its vulnerability to climate change

Prepared for the Australian Government
Department of Climate Change and Energy Efficiency

by

the Secretariat of the Pacific Community in conjunction with CSIRO

Australian Government

International CLIMATE CHANGE ADAPTATION Initiative

Secretariat of the Pacific Community
Noumea, New Caledonia, 2011

Disclaimer:

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List of abbreviations

ADB	–	Asian Development Bank
AusAID	–	Australian Agency for International Development
CO_2	–	carbon dioxide
ENSO	–	El Niño/La Niña-Southern Oscillation
ESCAP	–	Economic and Social Commission for Asia and the Pacific
FAO	–	Food and Agriculture Organization of the United Nations
FICI	–	food import capability indicator
FSM	–	Federated States of Micronesia
GDP	–	gross domestic product
HIES	–	household income and expenditure survey
IPCC	–	Intergovernmental Panel on Climate Change
NCD	–	non-communicable disease
NGO	–	non-governmental organisation
PACC	–	Pacific Adaptation to Climate Change
PNG	–	Papua New Guinea
PRISM	–	Pacific Regional Information System
SPC	–	Secretariat of the Pacific Community
SPREP	–	Secretariat for the Pacific Regional Environment Programme
UNDP	–	United Nations Development Programme
USP	–	University of the South Pacific
WHO	–	World Health Organization
WTO	–	World Trade Organization

Executive summary

This report deals with food security and climate change in 15 Pacific Island economies in terms of the four traditional food security pillars:

- *adequacy* (enough food on a consistent basis, either through local production or imports or food assistance from outside sources);
- *availability* (ability of households and individuals to acquire food);
- *stability* (resilience of food supplies to external shocks, such as natural disasters);
- *utilisation* of food at the household level, especially by those with low incomes (requiring that people are healthy enough to process the food internally, and have adequate safe water and sanitation and food hygiene and child-care skills.

In the Pacific context, *safety and nutrition* (food that is fresh or properly preserved and contributes to a healthy diet) are equally important and are included as a fifth pillar. Adequate food security has existed only intermittently in the region in the past and food shortages and famine conditions continue to occur, largely as a result of natural weather-related events.

The report first describes the present state of Pacific food security with regard to the five pillars. It then assesses the likely impact of climate change, describes a range of possible responses to ensure future food security, identifies knowledge gaps that need to be addressed to enable informed adaptation response decisions, and outlines present government and development partner responses in the area of climate change and food security. Finally, it discusses options for improving food security in the face of climate change. Key findings of the report are presented below.

Present state of Pacific food security

Food production – the adequacy *food security pillar*[1]

- Per capita food production has been falling in nearly all Pacific countries over the past decade, even in countries with little population growth.
- Agricultural crop production is important in most of the countries, especially in Melanesia, including Timor-Leste, where it is the main source of employment. It is also important in the larger Polynesian countries (Samoa and Tonga), and moderately important in the Cook Islands, Kiribati, Federated States of Micronesia (FSM) and Tuvalu. Agriculture's contribution to economic output is limited in the Marshall Islands and Niue and insignificant in Nauru and Palau.
- Livestock production has been steadily increasing around the region since the 1960s in nearly all countries, especially in poultry and eggs.
- Fisheries production has increased across the region in recent years, but only in offshore fisheries mainly targeting tuna and dominated by foreign-owned fleets. Production for local consumption from coastal or inshore fisheries has not increased in the past decade.

Food consumption – the availability *food security pillar*

- Traditional Pacific diets are based on starchy root crops supplemented by coconuts, fish and sometimes livestock products. But these traditional foods are being replaced by imported foods (most notably in urban areas). In particular, white rice and refined flour, along with processed, usually tinned, meats and fish, which have become popular due to changed dietary preferences and ease of storage and preparation, even though imported foods are sometimes more expensive.

1 *The data used in this report refer to both commercial and subsistence food production and consumption.*

- Dependence on imported foods varies widely between commodities as well as between and within countries.
- Fresh fish remains a major source of protein in the Pacific diet, although recent years have seen a significant increase in the proportion of meat-based protein in nearly all countries.

Health and nutrition – the safe and nutritious *and* utilisation *food security pillars*

- The proportion of adults at risk of non-communicable disease, associated with the transition toward imported foods and less active lifestyles, is high across the region and highest (60–80%) in the atoll micro states, mainly in urban areas. Obesity rates across the region are amongst the highest in the world. The resulting increase in non-communicable diseases from this factor and others is straining national health systems.
- Undernutrition is common among urban infants and young children in some Pacific countries, with Timor-Leste having the highest proportion of underweight children (nearly 50%) in the region; Papua New Guinea (PNG), with 25% of children underweight, also has a serious problem in this regard. Deficiencies in iron, iodine and vitamin A are also widespread.
- Poor living conditions related to increasing urban poverty (e.g. lack of water and sanitation and food safety issues) affect proper utilisation of food in households.

Markets and trade – the stability *food security pillar*

- Variable inflation rates, poor economic growth, negative trade balances, global food price rises and increasing household dependence on commercial markets affect almost all the countries in the region and have added to food vulnerability risks.
- National food vulnerability ranges from very low in the bigger Melanesian countries with a large agricultural base to extremely high in some atoll micro states, though populations in rural areas that are less dependent on imported foods have lower vulnerability.

Environmental sustainability – associated with the stability *food security pillar*

- Traditional food systems, supported by controls and prohibitions associated with customary land tenure, have generally been environmentally sustainable. However, these traditional practices have declined in both terrestrial and aquatic ecosystems in recent decades.
- These systems have been partly replaced by more modern food production systems that have reduced crop, tree and livestock diversity and led to introductions of new species, some of which have dramatically changed the landscapes in many countries.
- Environmental degradation and pollution resulting from these changes have undermined ecosystem health and therefore food production potential, and have increased vulnerability to climatic events.

Social and economic issues– associated with the availability *food security pillar*

- Numerous social and economic issues interact to contribute to declining food security status. Issues include:
  - widespread lack of clarity in land tenure and lease of customary land, intensified by rapid urbanisation, poor governance and lack of technical and administrative capacity, discouraging sustainable land use practices to support long-term agricultural productivity;
  - low land productivity resulting from inadequate resource management, exacerbated by loss of human productivity related to poor nutrition, rural-urban drift and lack of interest in agriculture, especially on the part of youth;
  - population growth, which adds to pressure on resources and increases poverty and hunger, especially in urban areas; and
  - deteriorating terms of trade and international agreements that may conflict with food security goals.

Likely impact of climate change on food security

Observed climate trends

- In line with global trends, mean annual air and water temperatures in the Pacific have been warming for several decades.
- The southern Pacific is generally becoming drier while the central equatorial Pacific is receiving more rainfall (though still subject to serious periodic drought).
- The incidence and severity of natural disasters, most of which have affected food production and in some cases resulted in the need for food aid to prevent famine, have increased over the past 50 years.

Projected impacts on food security

- Climate change will affect food production all along the food chain, from primary production source to end-point consumption/export.
- Warmer temperatures could benefit some crops, for example by extending fruiting seasons, but wetter or drier conditions may offset any gains.
- Important cash crops (sugar, coffee, copra and cocoa) are likely to experience production, yield and quality declines due to changed climatic conditions.
- Climate change will alter agro-biodiversity across the Pacific and change pest and disease regimes, both of which will adversely impact on agricultural production.
- Coastal fisheries harvests could be reduced by 50% by 2100, leaving only a few countries able to obtain half their daily protein needs from this source. The main causes in the near term will be increased overfishing and coastal pollution and in the medium and long term, the direct effects of global warming and ocean acidification on fish and invertebrate species, and the indirect effects on their habitats (coral reefs, mangroves, seagrasses and intertidal flats).
- Freshwater fisheries and aquaculture may benefit from warmer, wetter conditions.
- Offshore fish stocks are expected to increase in the medium term and move further east due to changing ocean currents, resulting in higher catches (and foreign exchange earnings) in some Polynesian and Micronesian countries and, in the long term, lower catches in Melanesia.
- Projected rising sea levels are likely to affect food security, particularly in low lying atoll countries and coastal areas of high volcanic islands through loss of land to erosion and salinisation. Such effects are generally longer term and could have a major impact on regional food production later this century.
- Projected increases in diet-related human health problems will affect food security through lowering individual productivity and employability (i.e. less ability to grow food or earn income to buy food).
- Further along the food chain, climate change impacts may damage infrastructure, especially transport systems.
- Imported foods may become more expensive due to production changes elsewhere.

Future options

Opportunities exist in many Pacific countries for developing more productive, climate-resilient and sustainable agriculture and fisheries systems through measures that can be taken along the food supply chain. At the preharvest stage, these include, among others, evaluation of existing and potential crop varieties and crop and livestock production systems for their climate resilience, and innovative farm management techniques; improved understanding of climate change effects on present commercial crops and pest and disease regimes; cost-benefit studies of increased access to irrigation and water efficiency technologies; evaluation of the potential of aquaculture as a supplementary food supply source; and improved understanding of how present environmental problems, overexploitation of resources and pollution affect the climate resilience of food production capabilities.

In fisheries, such measures include developing new fishing technologies to access local tuna resources, analysing the costs and benefits of alternative uses of tuna resources, improving the capability for predicting tuna abundance and distribution, evaluating the potential harvest levels of small pelagic species, and assesing the vulnerability to climate change of deepwater demersal species taken by coastal fisheries.

At the postharvest stage, measures include improving food processing and storage strategies and related infrastructure. For example, small ports and roads for distribution and marketing need to be built or made more resilient to expected climates. The potential contribution of increased urban and peri-urban food production under climate change must also be assessed.

Supporting measures include understanding and overcoming political, cultural and social constraints related to land tenure, education and governance that influence livelihoods and adaptive capacity. There is a need for improved monitoring and assessment of consumption and nutrition trends to identify climate impacts and develop remedial steps. The implications of existing international trade liberalisation commitments on long-term food security should also be considered.

Countries that favour imported food supplies to satisfy most of their food demand, or are obliged to do so due to lack of domestic production, will have different priorities from countries focusing on producing their own food. Significant increases in national incomes will be required to overcome foreign exchange deficits to enable purchase of better quality food, especially through private sector involvement and increased trade. Increased value-adding in food production systems and strengthening export infrastructure (ports, roads and export-import facilities) for climate resilience are also needed.

Even with increased emphasis on domestic production, most Pacific countries will continue to rely on food imports to meet their needs, especially in the event of severe natural disasters. Some key response elements include developing intraregional food trade, awareness campaigns and education on healthy diets, and filling the considerable knowledge gaps on climate change impacts on food security.

Building national capacities to effectively manage present and future food security will remain an on-going objective for development partner financial and technical assistance to the region. However, given existing domestic capacity constraints, considerable external technical and financial assistance will be required for new and on-going research and development projects by regional and international organisations, supported by national capacity building.

In particular, building the capacity of regional institutions in the Pacific to supply specialised scientific and technical support in areas where it is not practical to sustain such expertise at the national level will be an important target for development partner support. For the medium term, national governments could set up multidisciplinary expert teams within government to coordinate the activities of external agencies and to ensure that the countries' interests are best served, until their own capacity to maintain food security is sufficiently developed.

Better regional coordination and alignment of technical assistance flows at the national and regional level remain a high priority. The 2010 Framework for Action on Food Security in the Pacific offers a broad framework for improved coordination and harmonisation of food security measures. Development partners must be willing to provide a better integrated package of services, rather than independent delivery mechanisms, to ensure that countries can effectively absorb increased assistance.

General recognition of the need for an increased food supply is overshadowing previous optimism that world supplies were adequate and only needed more equitable distribution. In line with this thinking, development partners of Pacific countries are now beginning to focus more on food security, including climate change impacts and the need for improving resilience of food production systems.

The opportunity therefore exists to significantly strengthen the Pacific region's food security position and build resilience to future climate change impacts, especially in the smaller atoll countries where the challenge is greatest.

Introduction

The purpose of this report is to assess the current food security issues in the Pacific region, the underlying drivers and trends that are likely to affect national and regional food security in the future and the impact of projected climate change on food production, and to suggest options for improving food security.

The accepted definition of food security is contained in the Declaration of the 2009 World Summit on Food Security[1]:

> *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.*

The Declaration notes that food security has four pillars: *adequacy* of food supplies (enough food on a consistent basis, either through local production or imports or food assistance from outside sources); *availability* of food supplies (ability of households and individuals to acquire food); *stability* of food supply (resilience of food supplies to external shocks, such as natural disasters); and *utilisation* of food at the household level, especially by those with low incomes (requiring that people are healthy enough to process the food internally, have adequate safe water and sanitation, and have basic food hygiene and child-care skills). In the Pacific context, the term *safe and nutritious* in the definition (food that is fresh or properly preserved and contributes to a healthy diet) is equally important and is included here as a fifth pillar.

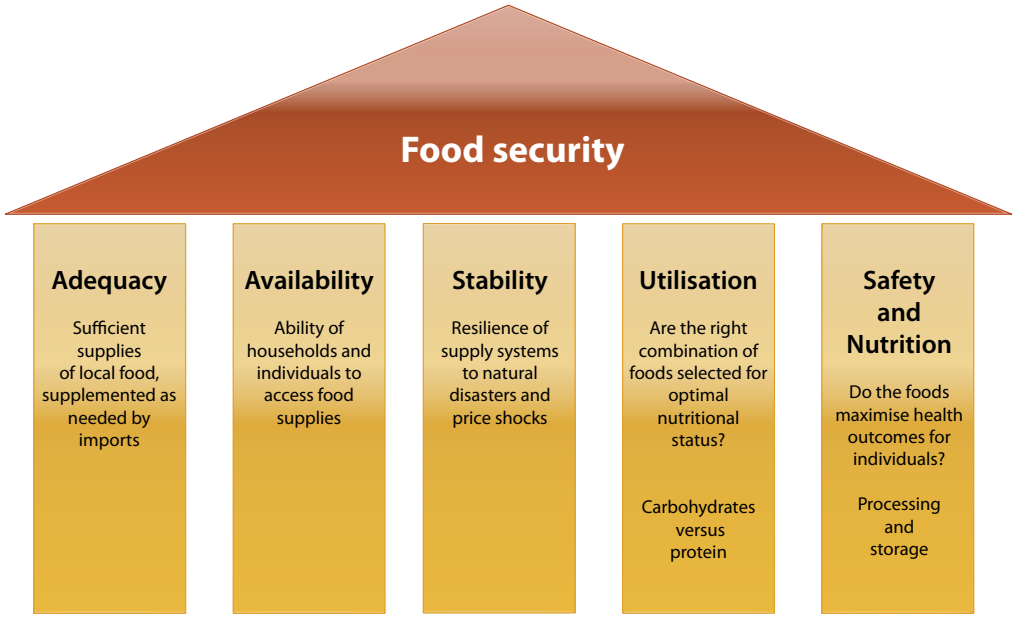

Figure 1: Food security for a country and its population depends on five pillars

The report deals with food security in 15 Pacific economies in three cultural groups – Melanesia, comprising Fiji, Papua New Guinea (PNG), Solomon Islands, and Vanuatu, as well as East Timor, or Timor-Leste;[2] Polynesia, comprising the Cook Islands, Niue, Samoa, Tonga, and Tuvalu; and Micronesia, comprising the Federated States of Micronesia (FSM), Kiribati, Marshall Islands, Nauru, and Palau – all of which are independent states except Niue. From a food security viewpoint, it is important to note that most of the land and the bulk of the population are in Melanesia, mainly on high volcanic islands with rich soil where agriculture is the main source of employment and livelihoods. Two Polynesian countries, Samoa and Tonga, have generally adequate land resources for agricultural subsistence, while the remaining eight "micro" states have very limited land resources and agriculture.[3] Conversely, fish consumption per capita is lowest in most of Melanesia, about twice as high in the larger Polynesian countries, and three or more times as high in the micro states.[4] Thus, for most purposes, the region is divided into three: the five countries of Melanesia (including Timor-Leste); Samoa and Tonga; and eight micro states – Cook Islands, FSM, Kiribati, Marshall Islands, Niue, Nauru, Palau and Tuvalu.

Food security as defined above has existed only intermittently in the region. The gradual eastward and southward migration of the original island settlers was largely due to food insecurity resulting from natural disasters – mainly cyclones and droughts that ruined crops – and population pressure. In more recent history, there is evidence of occasional and seasonal hunger and famine.[5] In PNG, for example, famine was said to be not uncommon in pre-colonial times, and there was severe famine as recently as during the 1997 El Niño.[6]

Traditional coping mechanisms for maintaining food security included diverse crops, farming and harvesting systems and ways of preserving foods, egalitarian resource tenure, communal mutual-help systems, wild food reservation areas, and migration to other islands.[7] Since the early twentieth century, a common response to food shortages caused by natural disasters has been to provide temporary food aid from elsewhere in the country or from another country. Migration in such circumstances is now rarely an option due to immigration policies, although migration for other purposes (e.g., seasonal employment) is a feature in some Pacific nations.

The introduction and promotion of imported foods have led to changes in people's tastes and diets, and all countries today depend to some extent on imported foods. Increased consumption of imported foods, especially highly processed packaged foods, has been linked to the growing problem of non-communicable diseases across the region (for example, diabetes, obesity and micronutrient deficiencies).

Pacific populations are growing in some areas, declining in others. Growth rates in Melanesia including Timor-Leste are high, but generally low elsewhere in the region[8] partly due to emigration. However, there is increasing movement from rural communities to urban areas associated with increasing poverty in nearly all the countries.

Over the past decade, food security in the region has been undermined by poor economic performance, declining income per capita, civil unrest, political instability, law-and-order problems, land access issues and inadequate governance.[9,10] The status of food security in the Pacific is, therefore, the product of a complex equation. In the past, the main variables were natural disasters and population pressure, to which can now be added food imports and rising prices, health risks, political instability, land tenure issues, urbanisation and governance problems.

Global climate change is emerging as a new and potentially significant factor in the equation, introducing long-term uncertainties into food production processes and adding to the burden of weather-related natural disasters.

Endnotes:

1 FAO. 2009. *Declaration of the World Summit on Food Security.* World Summit on Food Security, Rome 16-19 November 2009. Rome. (http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/WSFS09_Declaration.pdf)

2 Timor-Leste lies at the southwestern edge of the tropical Pacific Ocean, populated largely through southward rather than eastward migration.

3 McGregor, A.M., R.M. Bourke, M. Manley , with R. Deo, and S. Tubuna. 2008. *Pacific Island Food Security in the 21st Century: Situation, Challenges and Opportunities. Draft.*

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

5 See, for example, Currey, B. 1980. Famine in the Pacific: Losing the Chances for Change. *GeoJournal 4.5: 447–446; and Diamond, J. 2005. Collapse: How Societies Choose to Fail or Survive. London: Allen Lane.*

6 *Allen, B.J., and R.M. Bourke. 1997. Report of an Assessment of the Impacts of Frost and Drought in Papua New Guinea. Port Moresby: AusAID.*

7 Simatupang, P., and E. Fleming, eds. 2001. *Food Security in Southwest Pacific Island Countries. Proceedings of a Workshop Held in Sydney, Australia, December 12-13, 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. Available: http://www.uncapsa.org/publication/cg40.pdf

8 *According to Pacific population data of SPC, as updated September 2010.*

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

10 Australian Agency for International Development (AusAID). 2009. *Tracking Development and Governance in the Pacific. Canberra.*

Part 1: Food security in the Pacific – current issues

Section 1. Food production and productivity: Addressing the *adequacy* pillar of food security

The agricultural sector, which includes fisheries and forestry, is of vital importance in Pacific nations. At present, crop agriculture is the most important sector in Melanesia, including Timor-Leste, where it is the main source of employment, and also important in the larger Polynesian countries (Samoa and Tonga), Cook Islands, Kiribati, FSM and Tuvalu. Agriculture's contribution to economic output is limited in the Marshall Islands and Niue and insignificant in Nauru and Palau. Subsistence food production forms a significant part of household income, and more than 50% in some countries, although it varies widely among and within countries.[1] Fisheries are important in all the countries.

Traditional food production is based on agro-forestry – seasonal and perennial crops among fruit and other trees, complemented, and sometimes dominated, by dependence on a wide range of wild foods and other products and services (such as fuel and medicines) of terrestrial, freshwater and marine origin.[2] These traditional systems, and commercial farming and fisheries have been well described elsewhere.[3, 4] However, it is noteworthy that structurally complex agro-forestry systems buffer crops from large fluctuations in temperature, keeping crops closer-to-optimal growing conditions. Shade trees protect crops from lower precipitation and reduced soil water availability and improve soil water infiltration. Such agro-forestry systems also protect crops from extreme storm events.

Agroforestry system, Vanuatu

Soil erosion caused by land clearance, Fiji

The widespread trend to cash cropping over recent decades has removed much or all of these benefits. It has also led to shortening of the fallow period with consequent soil fertility loss and weed and pest problems.[5] This is most evident in parts of Melanesia, where farmers are changing from shifting cultivation, which maintained soil fertility and controlled erosion, to annual cropping of the same land. This has increased soil erosion, reduced yields and decreased household food security.[6]

Regionally, agriculture production has been steadily increasing since the 1960s for nearly all crops. Annual growth rates of production in the overall agriculture sector have slowed down since the 1990s in most countries for which there are data, except for modest gains in Kiribati, Solomon Islands and Tonga. There have been actual declines in agricultural production in this period in Fiji, Samoa and Tuvalu. Sector contribution to GDP has also declined, steeply in some countries, since the 1990s, except in PNG, Solomon Islands and Timor-Leste,[7] where the

share has increased (Table 1). Not all production is associated directly with food security. PNG has important export-oriented commodities, such as the coffee industry cocoa, coconut, and oil palm.[8] These industries do, however, provide household income to buy food.

Crop production increases are all attributable to increases in area farmed. Crop yield, or productivity, in the region has shown very little improvement and in several cases declined in recent years, as shown in Appendix Table 1.[9]

It should be noted that the food production and livestock data in the Appendix Table and in Table 1 below are based on Food and Agriculture Organization of the United Nations (FAO) data, which include all domestic production of crops, livestock and fish, including non-commercial and subsistence production. Fisheries production data, shown separately in Figure 1, also include both subsistence and commercial production.

Importantly, food production per capita has declined in all countries except Kiribati and Samoa since the early 1990s, associated with an increased import dependency in several countries (Table 1 and Figure 2). The decline in food production per capita is occurring even in other Polynesian countries with little net population growth. Very limited reliable data are available for Timor-Leste. Production of the main staples there (maize, rice and cassava) has increased above pre-independence levels since 2002. However, while local maize is presently adequate for domestic needs, around two thirds of domestic rice requirements are imported.[10]

Table 1: Land area, food production indexes and agriculture growth, Pacific island countries

Country	Land Area (km^2)	Net food production per capita index (base 1999–2001		Livestock production index (base 1999–2001)		Annual Growth Rate of Agriculture (%)		Share of Agriculture in Total GDP (%)	
		1990–1994	2000-2008	1990–1994	2000–2008	1990s	2000–2008	1990s	2000–2008
Melanesia									
Fiji	18,376	111.6	94.9	99.0	104.5	1.0	-0.9	17.8	14.2
Papua New Guinea	461,690	100.6	96.6	82.4	110.0	4.8	1.6	31.4	35.4
Solomon Islands	29,785	104.4	97.9	88.2	108.3	2.3	4.9	31.0	33.0
Timor-Leste[a]	18,900	106.8	101.4	108.4	121.1	2.4	0.9	33.8	31.1
Vanuatu	12,189	119.4	92.5	93.6	92.6	3.0	1.9	17.2	14.9
Larger Polynesian Countries									
Samoa	2,934	91.6	101.3	94.0	104.3	1.9	-2.4	19.5	12.9
Tonga	696	106.6	101.3	93.4	96.8	0.3	1.6	33.6	26.8
Micro States									
Cook Islands	180	89.0	74.6	51.8	80.6	8.3	3.2	15.3	12.4
Fed. States of Micronesia	702	99.4 (1995-99)	98.1	100.0 (1995-99)	100.1	NA	NA	NA	NA
Kiribati	726	90.4	104.8	83.8	114.0	-2.4	1.3	25.5	24.3
Marshall Islands	720	NA	NA	NA	NA	NA	NA	NA	NA
Nauru	21	101.8	100.6	95.2	100.3	NA	NA	NA	11.4
Niue	259	NA	NA	NA	NA	NA	NA	NA	NA
Palau	475	NA	NA	NA	NA	NA	NA	4.7	3.5
Tuvalu	26	119.4	92.5	71.6	104.0	1.3	-4.7	23.5	16.8

Note: NA = no available data. Sources: Agriculture share of GDP 2009: ADB 2011[11]; Agriculture growth and in GDP: Source: ADB 2009.[12] Food and livestock production indexes: Sombilla 2010;[13] a 2008 (http://www.theodora.com/wfbcurrent/Timorleste/Timorleste_people.html)

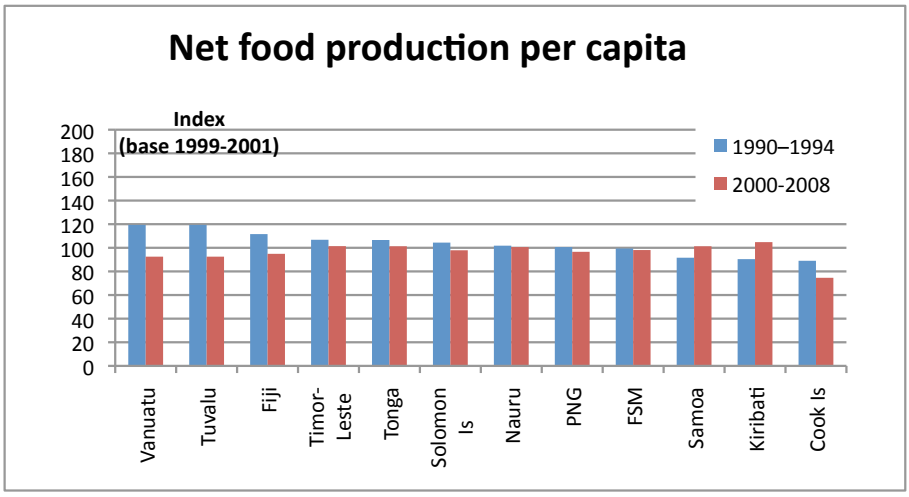

Figure 2: Comparison of country net food production per capita for the periods 1990–1994 and 2000–2008 showing a decline in all countries except Kiribati and Samoa

Livestock production has been increasing around the region since the 1960s, especially poultry and egg production. Overall, poultry and pigs form an extremely important source of protein for many Pacific Islanders. Farming of ruminants, such as cattle, sheep and goats is carried out mainly in Melanesia and the larger Polynesian countries.[14] The livestock production index has shown strong gains in nearly all countries (Table 1 and Figure 3), which reflects the global trend for increased meat in diets.

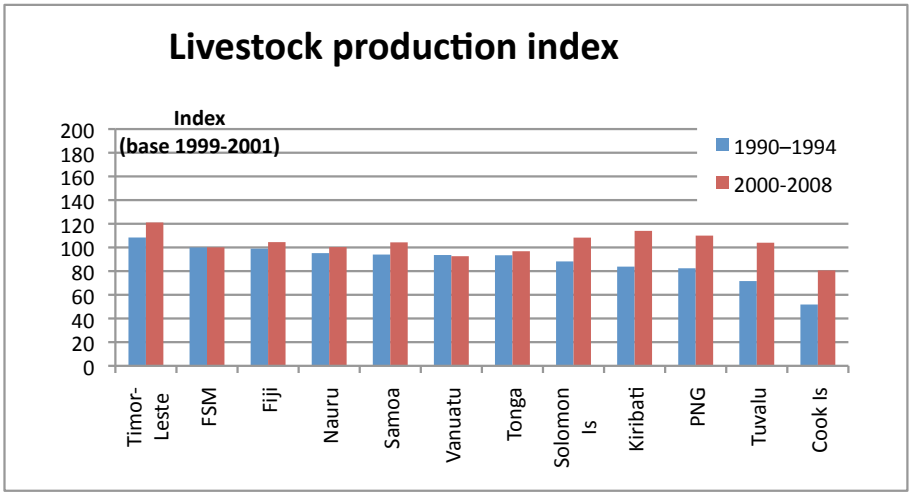

Figure 3: Comparison of country livestock production for the periods 1990–1994 and 2000–2008 showing a general increase in production except in FSM and Vanuatu.

Fisheries production has also increased across the region over the past decade (Figure 4). The largest producers were the Melanesian countries. The marine fisheries are divided into coastal, which includes subsistence (home consumption or gifts) and commercial fishing in inshore and offshore areas, and offshore fisheries. Nearly all of the increase in the past decade has been in offshore production, mainly by foreign-owned fleets targeting tuna.[15] Illegal offshore fishing adds about a third to the reported catch in the western central Pacific (2000–2003 data).[16]

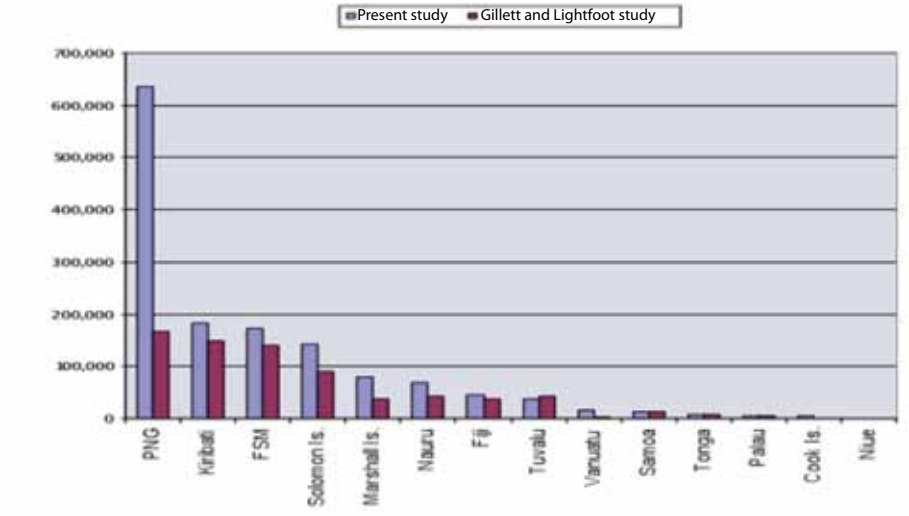

Figure 4: Pacific fishery production by country, 1999 and 2007
Note: Present study refers to 2007; Gillett and Lightfoot study refers to 1999.
Source: Gillett, R. 2009. Fisheries in the economies of the Pacific Island countries and territories. *Pacific Studies Series*. Manila: ADB.

Coastal fishery production showed little change, implying that both commercial and subsistence coastal fisheries may be close to maximum yields in some areas.[17] However, based on average maximum sustainable coral reef yields, most countries still have scope for increased production.[18] The notable exception is Timor-Leste where reef area, a maximum of 300 km^2, suggests maximum yields of 900 tonnes of fish per year or less than 1 kg per person per year.[19] Freshwater fisheries are significant only in the large Melanesian countries, mainly PNG, with smaller fish catches in Fiji and the Solomon Islands. Fiji also harvests some 8,000 tonnes of freshwater mussels annually.[20]

Fish farming, or aquaculture, for food in the Pacific is insignificant at present, with small harvests of tilapia in Fiji, PNG and Vanuatu. Other crops, such as shrimp, are also produced for domestic consumption and export.[21]

Key findings

Overall the region has become less food secure over recent decades. Key trends include

- falling food production per capita in most countries;
- low growth in crop production, with stagnant or declining yields;
- general increases in offshore fisheries and livestock production;
- increased dependence on food imports.

The ability of the Pacific region to expand food production significantly to enhance food security faces several critical biophysical and socioeconomic constraints and barriers. These include

- lack of smallholder market integration;
- lack of knowledge/implementation of sustainable farm management practices;
- limited arable land due to the small size of many countries, unsuitable topography for some staple crops, and land use for export crops;
- land tenure issues, such as lack of clarity over the terms of both ownership and lease of customary land and increased pressure on land use due to population growth (Appendix 1);22
- rapid urbanisation and lack of interest in agriculture among youth, resulting in loss of production on suitable land and loss of skilled rural labour;
- lack of national policies and programmes to improve and support agriculture production, for example through public-private partnership;
- limited investment in agricultural support services (research, extension);

- inadequate governance, especially limited technical and administrative capacity.

Improved integrated farm management techniques and agricultural intensification could contribute to increased terrestrial food production, but it is clear that many countries in the region face a major challenge to increasing per capita food production, especially with projected population growth trends, irrespective of climate change. For some countries increased domestic utilisation of marine food sources, especially tuna, offers considerable potential for maintaining adequate food security. Intraregional trade from countries with food surpluses to those with deficits also offers some scope.

Section 2. Food consumption: Addressing the *availability pillar of food security*

Traditionally, Pacific diets have been predominately based on starchy root crops supplemented by coconuts, fish, and sometimes livestock. However, in the past two decades these local staples[23] have been progressively replaced by imported foods, especially white rice and refined flour. For example, Solomon Islands' annual national consumption of imported cereals, nearly all rice, was around 100 kg per capita in 2007, which was double the consumption per capita in 2002. Consumption tripled in Samoa and Cook Islands in the same period.[24] In Vanuatu and Fiji, the average cereal consumption is about 80 kg and in PNG, about 55 kg.[25] These levels, while less than those in Indonesia and the Philippines at 120–140 kg/person/year), are well above those in Australia (20) and Europe (6). This dietary shift has been largely driven by consumers' changing tastes, ease of storage and preparation, and sometimes cost.[26]

The household income and expenditure survey (HIES) analysis conducted as part of this report (Appendix 2) reveals the differences in food consumption between two atoll countries (Kiribati and Tuvalu) and two fertile island countries (Tonga and Vanuatu), and between urban and rural areas, for lower-income groups. Sugar and rice are the top two energy (calorie) sources in the two atoll countries, representing one quarter to half of the recommended daily energy consumption of 2,100 calories for an average adult. In Tonga, the top two energy-giving foods are imported chicken pieces and local cassava. In urban Vanuatu, it is bread and rice, but in rural Vanuatu, a combination of local vegetable crops provides most energy. The data show that food consumption patterns differ widely between countries in the region and that few generalisations can be made.

Based on minimum energy consumption requirements, populations in five of the six countries for which FAO data are available (Table 2) have adequate calorie intake on average, and decreasing proportions of the populations have inadequate calories. Timor-Leste, where calorie undernutrition has been rising, is the exception. The average proportion of underweight under-5 year old children in developing countries is 20% according to the World Health Organization (WHO), a figure exceeded in PNG and especially in Timor-Leste.

Households in Kiribati, Tuvalu and Vanuatu spend most of their cash allocated to food on bread and cereals (mainly rice). In Tonga, meat and poultry dominate expenditure. Foods not purchased, i.e. home produced, in the atoll countries are mainly fish and seafood, and to a lesser extent vegetables. In the larger fertile islands, vegetables and fruits dominate home production. These foods, together with in-kind (bartering and gifts) produce, account for about one third of food consumed in three countries, with two-thirds met by cash purchases.

Meat consumption has been steadily rising across the region, with annual per capita consumption increasing linearly from about 34 kg to 52 kg between 1973 and 2003.[27] The increase can largely be attributed to increases in imported meats, especially poultry, mutton flaps and tinned meats. The average consumption of meat may be approaching the same average level as fish consumption (which also includes imported canned and frozen fish) and represents an important aspect of the dietary shift in the Pacific.

Fish consumption in the Pacific on a per capita basis is among the highest in the world, particularly in the Polynesian and Micronesian atoll countries (Table 2). In the larger islands of Melanesia, some inland

rural areas have no or very limited access to marine fish. However, the great majority of rural coastal communities, even in Melanesia, have very high fish consumption levels. Timor-Leste has the lowest national fish consumption among the countries, partially due to the present small size of the Timorese fishing industry.[28] In some rural areas of Melanesia, freshwater fisheries and aquaculture supplement diets based on traditional agro-forestry produce. For most of the countries, more than 50% of fish consumption is sourced from domestic subsistence fishing, and up to 90% in rural coastal areas.[29]

For good nutrition, WHO recommends a daily protein intake of about 0.7 g of protein per kilogram of body weight per day, which should be derived from a variety of sources to prevent micronutrient deficiencies. While meat consumption is rising in some countries, fish is expected to remain a major protein source. Consumption of 35 (34–37) kg/person/year represents half the average daily protein requirement for Pacific Islanders. This is a useful benchmark or target for planning the contribution of fish to food security.[30]

On this basis, populations in the micro states and Samoa presently consume, on average, adequate fish. Elsewhere there is a shortfall. As the data for the four countries described above indicate, the shortfalls are mainly in urban areas of fish-deficit countries. For inland populations in PNG, where fish is presently largely unavailable, a reasonable target is 5 kg/person/year and the national suggested target for PNG is to maintain the present 13 kg.[31]

Key findings

Analysis of food consumption data highlights the

- increasing trend toward reliance on imported foods, especially in urban areas, for energy and protein needs;
- low proportion of local crops in the diet other than in rural areas;
- continuing importance of fresh fish to diets and household income in rural areas;
- growing importance of meat in the diets of many Pacific islanders.

The transition from local to imported foods has meant a growing dependence on foreign sourced food supplies and a corresponding decline in the contribution of domestic food production in Pacific diets. If these trends persist they will have increasingly significant repercussions for regional food security in the coming years, especially if the prices of international staples continue to be volatile.

Table 2: Total food and fish consumption, Pacific Island countries

Country	Total Food Consumption					Fish (fresh, canned, and imported frozen fish) Consumption (kg/person/year)				
	Food Consumption (kcal/capita/year		% Population Below Minimum Dietary Energy Consumption			Based on Studies in the 1990s	Household Income and Expenditure Surveys, Mainly During 2001–2006 [a]			Socio-economic Surveys in 2004–2007 [a]
	1990	2005	1990–1992	1995–1997	2003–2005		National	Urban	Rural	Coastal
Melanesia										
Fiji	2,592	3,001	8	5	<5	44.0–62.0	21	15	25	113
Papua New Guinea	NA	NA	NA	NA	NA	18.2–24.9	13	28	10	53
Solomon Islands	1,984	2,433	25	13	9	32.2–32.7	33	46	31	118
Timor-Leste	2,268	2,169	18	13	22	5[b,c]				
Vanuatu	2,498	2,575	10	10	7	15.9–25.7	20	19	21	30
Larger Polynesian Countries										
Samoa	2,614	2,769	9	10	<5	46.3–71.0	87	46	98	94
Tonga	NA	NA	NA	NA	NA	25.2–30.0, 58[d]	20	NA	NA	85
Micro States										
Cook Islands	NA	NA	NA	NA	NA	47.0–71.0	35	25	61	79
Fed. States of Micronesia	NA	NA	NA	NA	NA	72.0–114.0	69	67	77	96
Kiribati	2,589	2,854	8	5	5	72.0–207.0	62	67	58	115
Marshall Islands	NA	NA	NA	NA	NA	38.9–59.0	NA	NA	NA	NA
Nauru	NA	NA	NA	NA	NA	46.7	56	NA	NA	62
Niue	NA	NA	NA	NA	NA	49.0–118.9	79.3	NA	NA	50
Palau	NA	NA	NA	NA	NA	84.0–135.0	33	28	43	79
Tuvalu	NA	NA	NA	NA	NA	85.0–146.0	111	69	147	146

Notes: NA = no available data. Based on available food supply.
Source: Food consumption: FAOStat (faostat.fao.org); and ADB 2009[32]; Fish consumption, except Timor-Leste: Gillett 2009.[33]

[a] SPC. 2008.[34]; [b] Represents entire country. [c] United Nations Development Assistance Framework UNDAF 2009–2013 Timor-Leste. http://planipolis.iiep.unesco.org/upload/Timor-Leste/Timor-Leste_UNDAF.pdf; [d] Alternative estimate based on recent subsistence plus locally marketed coastal fish production, in Gillett (2009).

Section 3. Health and nutrition issues: Addressing the *safe and nutritious and utilisation pillars of food security*

A condition of the definition of food security is that it should provide "safe and nutritious food to meet… dietary needs and food preferences for an active and healthy life." The food preferences found in the Pacific today do not appear to be satisfying nutritional needs (or requirements). The most tangible evidence of food insecurity from this trend is the widespread double burden of malnutrition[35]—obesity and non-communicable diseases on the one hand and hunger and micronutrient deficiencies on the other.

Imported staples like rice, flour, and tinned meats, appear to have some advantages over local produce because they are sometimes cheaper and easier to prepare than traditional foods; have higher concentrations of carbohydrates and protein; and some have similar fibre, potassium and calcium content. However, compared to traditional foods they usually contain much more fat, are more energy dense, have much higher sodium content, and virtually no vitamins C or A. They also have a much higher glycaemic index rating than their local counterparts, which is especially detrimental for Pacific islanders, who are genetically susceptible to diabetes.[36] In countries with available data, calorie intake per capita[37] has been increasing, except in Timor-Leste (see Table 2).

The changing trends in dietary patterns have been accompanied by changes in lifestyle. The traditional Pacific way of life was very active, not only in agriculture, foraging and fishing but also in preparing the food itself. The availability of convenient imported foods has removed the need for much of this activity, especially in urban situations—and indeed has encouraged urbanization.

The combination of increasing consumption of imported staples and increasingly sedentary lifestyles has resulted in Pacific populations being not only among the most obese in the world, but also among the highest in prevalence of type 2 diabetes[38] (Table 3). It has also contributed to a number of other non-communicable disease issues, such as increased hypertension and cardiovascular disease. This is overwhelmingly an urban problem (Figure 5). Diabetes prevalence in the countries ranged up to 16% in urban Pacific areas.[39] By comparison, diabetes prevalence in 2000 in East Asia averaged less than 3% and in North America 6–8%.[40] The proportion of adults at risk of non-communicable disease is high across the region and highest (60–80%) in the atoll micro states. Treatment of such diseases takes up 27% of Samoa's total health budget, 18% of Tonga's health costs, and 11% of those in Fiji.[41] Such diseases not only create a financial burden on families, but also affect individual productivity and employability, exacerbating this burden.

The proportion of populations consuming inadequate calories (in countries with data) has fallen over the past decade, except in Timor-Leste (Table 2). Undernutrition in children under the age of five is a significant problem in FSM, Kiribati, Marshall Islands, PNG, Solomon Islands, and Vanuatu. Timor-Leste has the highest proportion of underweight children (nearly 50%) in the region (Table 3).

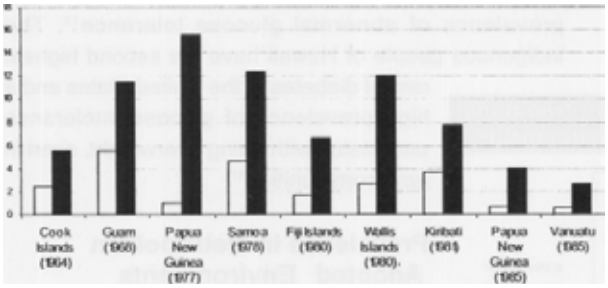

Figure 5: Diabetes Prevalence in Traditional and Urban Populations in Pacific Countries, Various Years (% population) White bars are traditional populations; black bars urban populations. Source: Foliaki, S., and N. Pearce. 2003. Prevalence and Causes of Diabetes in Pacific People. Pacific Health Dialog 10(2): 87–95.

Table 3: Hunger, non-communicable disease, and dietary energy consumption, Pacific island countries

Country	Proportion of underweight under-5-year olds (%). (Latest year)	Obesity Rate (%) (2002)	Diabetes prevalence 2000	% Population at high risk of NCDs[a] (year)	Anaemia Prevalence (%)	% Population <Minimum Dietary Energy Consumption	
						1990–1992	2003–2005
Melanesia							
Fiji	15.0 (1993)	NA	37,000	NA	32	8	<5
Papua New Guinea	24.9 (2000)	14–38	152,000	22 (2007)	45	NA	NA
Solomon Islands	11.8 (2007)	NA	13,000	46 (2006)	29	25	9
Timor-Leste	48.6 (2007)	NA	NA	NA	31.5 – 36.5[b]	18	22
Vanuatu	12.1 (1996)	12–34	6,000	NA	57	10	7
Larger Polynesian Countries							
Samoa	17.0 (1997)	47–66	4,000	34 (2002)	56	9	<5
Tonga	1.6 (1986)	42	3,000	NA	37	NA	NA
Micro States						NA	NA
Cook Islands	10.0 (1997)	40–50	700	72 (2004)	37	NA	NA
Fed. States of Micronesia (Pohnpei)	15.0 (1997)	NA	5,000	57 (2002)	40	NA	NA
Kiribati	13.0 (1999)	20–37	4,000	75 (2006)	25	8	5
Marshall Islands	13.0 (2007)	NA	2,000	60 (2002)	26	NA	NA
Nauru	4.8 (2007)	80	2,000	80 (2004)	11	NA	NA
Niue	0.0 (2002)	NA	<100	NA	7	NA	NA
Palau	NA	NA	1,000	NA	5	NA	NA
Tuvalu	1.6 (2007)	12–48	300	NA	23	NA	NA

Note: NA = no available data, NCD = non-communicable disease..
Sources: Hunger: Table 2, Annex 2 in AusAID 2009.[42] ; Obesity: World Health Organization 2003.[43] ; Diabetes prevalence: WHO (http://www.who.int/diabetes/facts/world_figures/en/index6.html);Population at high risk of NCDs: WHO STEPS (STEPwise approach to Surveillance) surveys; population aged 25–64; Anaemia: Timor-Leste Demographic and Health Survey;[44] Other countries: Hughes. 2006.[45]; Dietary energy: Data source: FAOStat (faostat.fao.org);a Non-communicable diseases—high cholesterol, hypertension, diabetes;
[b] In pregnant and non pregnant women.

Micronutrient deficiencies are also widespread. The prevalence of anaemia from lack of iron is reported to be 20% or greater, in both children and pregnant women, in 15 Pacific countries.[46] Iodine deficiency and endemic goitre are prevalent, especially in Fiji, PNG and Vanuatu.[47] Vitamin A deficiency, which causes eye damage and can cause morbidity and death, is a public health problem in Kiribati, Marshall Islands, FSM and PNG.[48] Most of these deficiencies can be attributed to poor diets and hygiene practices. Some countries have introduced such measures as nutrient fortification and nutrition programmes but micronutrient deficiency remains a major issue in the region.[49]

Nutrition programmes that promote greater consumption of micronutrient rich local foods have delivered encouraging results.[50] For example, the Pohnpei "Go local" programme over two years resulted in (i) an increased (110%) provitamin A carotenoid intake; (ii) a higher frequency of eating local bananas (53%), giant swamp taro (475%), and local vegetables (130%); and (iii) a greater dietary diversity.[51]

Proper utilization of food is necessary for food security. Food-handling and processing techniques pose health risks due to lack of food laws and awareness among populations in most Pacific countries. Consumers are exposed to foods high in fat, sugar and/or salt, adding to health and food insecurity risks. Examples that

have affected trade include cyanide in cassava; cadmium in taro; mercury, histamine and ciguatera in fish; and *Escherichia coli* in green leafy vegetables. Some foods remain on sale after their use-by date and/or have undergone temperature degradation.[52] Infectious diarrheal and parasitic diseases, many of which can be attributed to the consumption of contaminated food and water, remain a major cause of illness (morbidity) in many countries of the Pacific.[53]

Key findings

In terms of the nutritional and health dimension of food security, several key trends and issues are apparent. These include

- increased reliance on imported food, often of poor nutritional status, contributing to adverse health outcomes in the region;
- declining share of more nutritious local food in Pacific diets;
- increased consumption of meat and livestock products that may surpass, or substitute for, fish consumption, as the primary source of animal protein, with potential longer-term health repercussions;
- excessive dietary calorie intake, which is a common problem in many countries and, when combined with more sedentary lifestyles, has serious repercussions, especially in terms of the high prevalence of obesity;
- undernutrition in some countries, especially Timor-Leste, and widespread micronutrient deficiencies; and
- lack of, or failure to enforce, food safety regulations and standards, exposing Pacific populations, especially as urban populations grow, to risk of food contamination and related health issues.

All these factors have contributed to worsening health outcomes across the region. If the trend towards increased consumption of, and dependency on, less nutritious food imports persists, it is evident that the region is likely to become less food secure in a nutritional sense. This form of food insecurity will add to existing health burdens and become a major drain on the health budgets in all countries.

Section 4. Markets and trade: Addressing the *stability pillar of food security*

Market prices

The generally increasing reliance of households on commercial markets for food supplies has increased the exposure of households to food market trends and cash income risks, as well as production failure risks. Over the past decade food prices have exhibited considerable volatility affecting consumers' ability to purchase food and meet nutritional needs. Farm income volatility and farmers' inability to predict future income have also influenced local food production.[54] The United Nations Development Programme (UNDP)[55] estimated that on average across the region, a 10% fall in real incomes of households close to national poverty lines would result in a 5% rise in poverty incidence.

Pacific literature on food security often refers to "cheaper imported food" preferences. However, this is not always the case. For example, HIES data show that in nearly all countries where adequate data are available, the price of tinned tuna has been around twice that of fresh tuna per kilogram (Appendix Table 5). Fiji is a notable exception, having a tuna cannery. The preference for imported fish over cheaper local fish is an indication that such features as novelty, taste and convenience are more important than price. The rapid rise in rice consumption across the region may be another such indication of this conclusion, given that prices of imported staples have been rising. For example, in PNG, the price of imported rice increased by 350% between 1997 and 2007 (from 92 toea (US$0.46)/kg to 324 toea (US$1.10)/kg) while consumption rose from around 43 to 55 kg/person/year during this period.[56] Rice production in PNG is limited because the returns

to labour are much lower than for other crops and has required subsidies to maintain grower interest.[57] Fiji has price controls on some imported foods.[58] One effect has been to make locally produced rice, which accounts for about a quarter of demand, nearly twice the price (at US$0.70–1.00 per kilogram[59]) of imported rice. In East Timor, subsidies on the cost of imported rice have faced criticism by producers that it keeps the price of local rice down while the imported rice is generally eaten by wealthier consumers.[60]

However, the rapid rise in global staple prices, beginning with the 2007–2008 global price crisis, when prices more than doubled, and again in 2010–2011, when they increased even further,[61] mean that households in the Pacific relying on imported foods are facing escalating costs—unless price subsidies are maintained or introduced.

In some countries, e.g., Tuvalu, Samoa, Kiribati and the Cook Islands, the cost of food imports has exceeded the value of total exports, but trade vulnerability varies significantly across the region.[62] Based on the food import capability indicator (FICI) (Table 4), Melanesia is least vulnerable and food grains are minor imports: only 7% of total imports in PNG, 14% in Fiji, around 17% in the Solomon Islands, and 18% in Vanuatu.[63]

Trade

Much of the recent international literature and national development trends in food security support the assertion that "food security is best served by fair and fully functioning markets and not by policies to promote self-sufficiency."[64] However, during the global price crises of 2007–2008 and in 2010–2011, low stockpiles of staples and occurrences of natural disasters, especially in major exporting countries, led to export bans, such as of Russian wheat during 2010–2011. Some Southeast Asian countries, for example, are now re-emphasizing food self-sufficiency.[65] The emerging fragile global food situation is expected to deteriorate in coming decades.[66]

In addition, some Pacific shipping schedules are being reduced due to rising fuel costs, while the increasing frequency and severity of natural disasters is also likely to affect shipping routes and frequency. Imported food prices and availability could be affected.

In many of the Pacific countries (with the exception of PNG and Timor-Leste) trade balances have been deteriorating, as have food trade balances (which are negative throughout the region, and highly negative for all but the larger Melanesian countries (see Table 4). Continued deterioration of trade balances is likely to reduce the ability of countries to import food to meet increasing domestic demand, thus adversely affecting future food security.

The Pacific's main exports are predominately of agricultural and marine origin accounting for over 85% of the region's foreign exchange.[67] Exceptions are Timor-Leste, where energy exports are significant, and PNG where both energy and mineral exports are important. PNG, Solomon Islands (mainly copra and palm oil), and Fiji (mainly sugar) have significant commodity crop exports. Most other countries have either declining or insignificant agricultural exports, excluding fish.[68]

Almost all Pacific countries receive significant revenue flows from offshore fishing access fees paid by foreign fishing nations.[69] Fishing access fees are vital in several countries, contributing up to 40% of government revenue. In some, countries government revenue from this source exceeds GDP.[70] The heavy reliance on agricultural and marine exports makes Pacific countries potentially highly vulnerable to climate change.

The imported food expenditure shortfalls (due to negative trade balances) are often met indirectly through foreign aid that serves to cover foreign exchange shortfalls and, in several Polynesian and Micronesian countries, through remittances[71] from overseas.[72] Foreign aid per capita across the region is among the highest in the world and represents a significant income support mechanism.

Stagnant or falling real incomes per capita, typical of most Pacific nations in recent years, has resulted

in increased food insecurity, especially households' ability to buy imported foods. Real annual GDP growth from 1995 to 2008 across the region was only about 0.2%,[73] driven mainly by improved economic performance of PNG, and to a lesser extent, Timor-Leste and the Solomon Islands. During 1995–2003, growth in Pacific countries was slower than in countries in any other region of the world.[74] Overall, most of the Pacific nations have experienced very low GDP growth over the past decade.[75] Low economic growth projections and, in some countries, increasing populations imply that income per capita is likely to remain flat or decline.

The Pacific countries, often with donor support, are currently implementing trade-focused projects that aim to contribute to export revenue and reduce trade imbalances. These include supporting local enterprises for niche products, developing farmer supply chains and promoting sustainable agricultural production systems, developing organic and fair trade markets, facilitating market access and availability of major local staples, for example taro, and developing the virgin coconut oil market. While these measures, if successful, will contribute to domestic and export earnings, there is the possibility, as previous experience has shown, that such projects can attract growers away from food production for local markets, increasing reliance on imported food. Similar concerns would apply to the export of coastal demersal fish[76] from countries with inadequate coastal fisheries resources for future domestic consumption, especially in the Melanesian countries, Nauru and Samoa (see Appendix Table 3).

Key findings

It is clear that for many Pacific countries, poor economic performance over the past decade, especially in terms of foreign export earnings, has resulted in a worsening food import situation. Other trends are:

- the ability to meet the costs of imported food is not expected to improve substantially in the short to medium term;
- consumption of imported foods is rising, regardless of sometimes higher import than local product prices;
- most countries have a high export trade dependency on agricultural and fisheries products and are highly vulnerable to extreme weather related events and, in future, climate change impacts; and
- all countries have either negative or highly negative total and food trade balances, although the larger Melanesian countries appear better placed than many of the smaller island countries.

Overall, the trend of increasing reliance on imported foods, supported by foreign aid and remittances in many cases, is cause for concern, given the rising international prices of staples and volatile global markets.

Table 4: Trade, 2001–2009, and food import factors, Pacific island countries

Country	Currency	Total food imports ('000)	Latest year	Total food exports ('000)	Food trade balance	Total trade balance[a]	% Energy from Imported Food (year)	Imported in Total Food Expenditure (%) (year)[b]	Food Import Capability (FICI) 1990–2001	Food Security Vulnerability Assessment[c]
Melanesia										
Fiji	FJD	2,808,000	2009	1,230,300	Negative	Negative	58 (20-year average)	NA	0.17	Low
Papua New Guinea	PGK	4,625,008	2002	3,577,483	Slightly negative	Negative	17 (2006)	NA	0.12	Extremely low
Solomon Islands	SBD	1,926,600	2009	1,316,300	Slightly negative	Negative	21 (2004)	35–44 (2006)	0.15	Low
Timor-Leste[c]	USD	268,584	2008	49,207	Highly negative	NA	NA	NA	NA	NA
Vanuatu	VUV	31,086,000	2009	6,150,000	Highly negative	Highly negative	21 (1997) (Malo Island)	NA	0.46	Moderate (low)
Larger Polynesian Countries										
Samoa	WST	620,667	2009	123,695	Highly negative	Highly negative	NA	56 (2002)	2.59	Extremely high (moderate)
Tonga	TOP	324,445	2008	17,511	Highly negative	Highly negative	NA	45 (2001)	1.10	High (moderate)
Micro States										
Cook Islands	NZD	290,228	2009	4,396	Highly negative	Highly negative	NA	NA	1.84	Extremely high
Fed States of Micronesia	USD	155,208	2008	12,984	Highly negative	Highly negative	73 (2008) (Pohnpei)	39 (2005)	NA	NA
Kiribati	AUD	83,632	2007	11,655	Highly negative	Highly negative	NA	36 (2006)	1.56	Extremely high
Marshall Islands	USD	68,490	2000	9,124	Highly negative	Highly negative	NA	NA	NA	NA
Nauru	AUD	33,683	2005	4,959	Highly negative	Highly negative	NA	NA	NA	NA
Niue	NZD	10,968	2008	27	Highly negative	Highly negative	NA	NA	1.32	Extremely high
Palau	USD	NA	NA	NA	NA	NA	NA	81–84 (2006)	NA	NA
Tuvalu	AUD	18,386	2008	109	Highly negative	Highly negative	NA	NA	5.48	Extremely high

NA = no available data. Source: Trade: except Timor-Leste: Pacific Regional Information System.[77] Food imports, energy and FICI;[78] [a] latest year, varies between 2000 and 2009; [b] from household income and expenditure surveys; [c] Democratic Republic of East Timor 2009.[79]

Section 5. Environmental issues: Further addressing the *stability pillar of food security*

Subsistence farmers and fishers, who make up the majority of the populations in most countries,[80] depend directly on natural resources for their livelihood and the provision of a range of environmental goods and services, such as food, fuel, freshwater and climate regulation. The latter is particularly important in terms of protecting crops, livestock and coastal and freshwater fish stocks from floods, storm surge and high winds. These are all important natural environmental services related to maintaining food security.[81,82]

The value and vulnerability of natural environments have long been understood by Pacific populations, who used a wide range of coping mechanisms to accommodate the high climate variability that exists in the region. For example, diverse agro-forestry systems provide much of the food base; multiple varieties of taro, yams, coconuts, breadfruit, banana, and mango with different characteristics, ripening periods, and susceptibilities to disease, pests and resilience to natural disasters, are grown to ensure adequate and reliable production.[83]

The importance of a diverse system in controlling pests and diseases is well known. For example, the use of only two potato varieties resulted in a loss of production worth US$15 million in five highland provinces of PNG over six weeks in 2002-2003. The two high-yielding potato varieties grown were susceptible to the causative fungus, which thrived in the unusual, favorable weather conditions (chilling misty conditions with winds and rains) during the period.

Traditionally, maintenance of these systems was aided by measures associated with customary land tenure. For example, in Polynesian atolls, the concept of *raui* (restraint) involved a range of resource management practices, such as closed areas or seasons, and limits on harvests. However, in recent times enforcing traditional management practices has become more difficult, and such conservation practices have declined, in both terrestrial and aquatic ecosystems.[84]

The absence of reliable and consistent time series data on environmental conditions and ecosystem health makes it difficult to provide an accurate assessment of the state of the Pacific environment. The availability of information also varies significantly across the region. Nevertheless, although many countries lack good data sets on water quality, sediment loads, soil loss, vegetation cover, and agro-biodiversity, it is evident that many of the Pacific island ecosystems have undergone significant degradation in recent decades.

In particular, there has been a significant loss of primary forest cover mainly associated with development of export monoculture crops, especially in western Melanesian countries. PNG lost 0.5% annual of its forest cover per year over the last decade and the Solomon Islands losses have averaged 0.2% per year.[85] Soil erosion and sedimentation loads have increased, with subsequent adverse impacts on freshwater and coastal fish habitats, and a net loss of coastal mangrove forests. In the micro states, water availability to support crop production, poor waste management, salinization, water pollution and coastal erosion triggered by the removal of beach sand, have emerged as major issues in agriculture and coastal fisheries production.

Soil erosion caused by land clearance

Photo: Chris Roelfsema

In some countries, large-scale monoculture of sugarcane, coconuts, palm oil and other cash crops has made important contributions to national economies but has often come at a cost of ecosystem degradation. Large-scale clearing of forests has occurred in PNG and Solomon Islands, where an additional10,000 hectares are under development for oil palm plantations. Indiscriminate burning of vegetation and resulting soil erosion are widespread, especially in Fiji and PNG.[86]

Introduced animal and plant species are fundamental to the food security of the region; much of the food comes from introduced species like coconuts, cassava, taro, pigs, chickens and other livestock. Tilapia, a recently introduced freshwater fish genus, has become an important protein source in parts of Melanesia, notably in the Sepik and Ramu rivers of PNG.[87] The environmental trade-offs associated with the introduction of new species to boost food production remains contentious and are discussed in Part 2.

Livestock production has caused environmental degradation from waste mismanagement and overgrazing, resulting in increased erosion and weed invasion of pastures in several areas.[88] Large islands with high rainfall (for example, Fiji) are losing 20 to 70 tonnes of soil per hectare per year in some areas, primarily due to poor land-use practices.[89]

Continued development of large-scale monoculture agriculture, unless carefully managed, could affect food security through loss of suitable land and/or ecosystem services. Downstream effects of runoff would adversely affect coastal fish habitats and coastal fish production.

Various initiatives are being implemented to address some of these issues. Projects targeting mangrove rehabilitation, improved forest and integrated farm management practices (such as agro-forestry), coastal fisheries management and soil conservation, and pollution control, are underway in most countries in the region. Widespread adoption of these practices over large areas will be essential for maintaining terrestrial and marine productivity and underpinning long-term food security.

Key findings

Overall ecosystem health and productivity have deteriorated in most countries over the past few decades and these issues will need to be addressed if the productivity from agriculture and fisheries is to be sustained and improved in the long term. Reversing the impact of unsustainable human activities in both rural and urban areas represents a serious challenge to many Pacific countries. It will involve achieving the right balance between improved subsistence and semi-commercial agriculture based on traditional agro-forestry systems and well-designed, large-scale, export-oriented commercial agriculture in order to maintain environmental integrity and domestic food security. Sustainable management of freshwater and coastal fisheries will depend in part on reducing agricultural and urban pollution.

Section 6. Socioeconomic and political issues: associated with the *availability food security pillar*

Population. The population of the region, 10.1 million as of mid-2010, is growing at about 2% per annum and expected to double before 2050 (Figure 6). This has major implications for long-term food security. The high growth rates are predominately driven by Melanesia, especially PNG (Fiji is the exception) where the populations are highest, and in FSM and Nauru (Table 5). Birth rates are broadly comparable across the region although lower in the Cook Islands and Niue and, to a lesser extent, Fiji. Emigration has contributed to low net population growth in Fiji and some countries of Micronesia and Polynesia. However, Emigration may be declining across the region: Marshall Islands emigration has slowed since 2000,[90] and is estimated at 5.3 per 1,000 persons in 2010;[91] Fiji's emigration rate has declined gradually from 3.5 per 1,000 persons in 2000 to 2.5 in 2009; and Samoa's from 12 per 1,000 persons to 9 in the same period.[92]

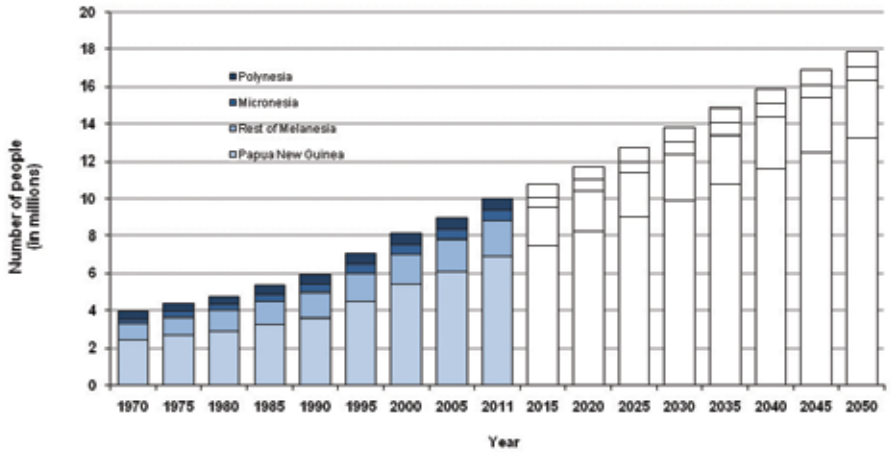

Figure 6: Population growth between 1970 and 2011 in Polynesia, Micronesia, Papua New Guinea and the rest of Melanesia, and projected growth to 2050.

Squatters houses standing alongside a former mangrove forest. Labasa, Vanua Levu, Fiji

Urbanisation. The rapid process of urbanisation that is underway in many Pacific countries has affected food security in several ways: (i) increasing the proportion of the population depending on commercial food markets (urban consumers tend to purchase disproportionately more imported food products than rural consumers), thus increasing dependency on external providers; (ii) lowering growth in agricultural production due to high levels of migration to urban areas by youth, who supply much of the rural labour force; (iii) breaking down traditional food insecurity coping mechanisms, especially social safety nets, in countries with rapid urbanisation rates, thus increasing vulnerability; and (iv) increasing poverty and poor living conditions leading to nutritional problems in parts of the Pacific.

Urban social problems, especially unemployment, have been evident, for example, in FSM,[93] Fiji,[94] Solomon Islands,[95] and Vanuatu.[96] Much of the future population growth in the Pacific is projected to be mainly in urban, peri-urban, and squatter areas, which could exacerbate poverty and environmental problems and thus increase health risks[97] as well as food insecurity.

Expenditure and income. Around 50% of all household expenditure in three of the four countries (two atoll and two fertile island countries) in the HIES analysis undertaken for this report (Appendix 2, and Section 2) was used to purchase food. In Timor-Leste, the proportion averaged 63%, and among the poor 76%.[98] For comparison, in selected developing countries of Asia, the proportion is 50–60%,[99] while in the US, low income groups spend 21% and high income groups spend 7% on food.[100]

In all four countries, rural households spent relatively more than did urban households on food purchases. Imported food items accounted for up to two thirds of total food expenditure on a national basis.

With regard to income, home produced sales accounted for 7% or less of total home income in urban areas of three countries (Kiribati the exception at 15%), while in rural areas, home produce accounted for 19–38%

of home income. Crop products were the dominant income source, followed by livestock in the larger countries, and fish/seafood in the atoll countries. Note that in general across the region, less than half of fish consumption is purchased, and the proportion purchased is always much lower in rural than in urban areas (Table 6). While this higher rural home production provides more food security, it also means more exposure to the potential effects of increasing weather extremes.

Similarly, in most countries with available data, the value of fish consumed significantly exceeds the value of fish sold. For example, in Tuvalu, the value of fish eaten in the household represents about 55% of household income, while sales represent only 3%. Kiribati and Tonga show more equal contributions. There is wide variation in the importance of fish across countries and between rural and urban residents, with rural areas much more dependent on fish. In the Solomon Islands, for example, subsistence and sales of fish contribute only 7% to household income in urban Honiara but 71% in Isabel Province (Table 6).

Increasing poverty and malnutrition. Poverty[101] has been increasing in Pacific countries for which data are available (Table 5). The proportion of poor has risen since the early 1990s, implying increasing hunger or undernutrition. Conditions could worsen if prices of imported foods continue to increase and local production is inadequate. Overnutrition (of calories) and associated non-communicable diseases pose an even greater health problem in some countries. Both forms of malnutrition, discussed in Section 3, not only create a direct financial burden on families, but also affect individual productivity and employability, exacerbating financial and food insecurity.[102]

Governance. To some extent, governance conditions[103] have contributed to aspects of food insecurity. In particular, limited institutional capacity to manage not only the food security implications of urbanization, but also land disputes and tenure, investment in agricultural research, management of coastal fisheries, promotion of widespread participation in agriculture, and/or providing efficient transport and infrastructure for food distribution.[104] Of the four capacities of state (institutional, technical, administrative, and political), most countries are particularly weak in technical and administrative areas.[105]

Effects of globalisation. Globalisation can affect Pacific food security in three ways: (i) through dependence on imported staples that may not be available when exporting countries face shortages in supplies as seen in the recent past; (ii) through World Trade Organization (WTO) or other international agreements that may foster increased dependence on imported foods through reducing trade regulation or fiscal measures; and (iii) through the extra-territorial economic, political and social forces that are said to have engendered a feeling of dispossession with resulting health and food security impacts in the populations.[106]

Trade liberalisation is a key component of the Pacific Forum countries' strategies for economic development, sustainability, and regional integration and is identified as a priority in the Pacific Plan.[107] However, there is a danger that a vicious circle of increasing reliance on imported foods could result from trade liberalisation measures. As suggested in a recent study: "integration with the cash economy and export promotion have supported urbanisation, urbanisation and export promotion have stimulated purchase of imported food; the cash economy has required ongoing aid and investment, and the current aid agenda encourages financial and trade liberalization."[108]

While trade liberalisation poses risks to regional food security, the extent of such risks is unclear. More detailed analysis is needed on the expected costs (including health risks noted earlier) and benefits of trade liberalisation measures on regional food production.

Key findings

Several socioeconomic and political factors are weakening Pacific food security:

- population increase, mainly in Melanesia;
- poorly performing economies in most countries;
- widespread land tenure and land access issues;
- governance capacity constraints;
- high urbanisation rates (especially in Micronesia and Polynesia)
- high urban unemployment and underemployment;
- high proportion of total household expenses, particularly in rural areas, in buying food;
- increasing poverty and malnutrition (under- or overnutrition);
- increasing dependence on imported food and national income support (especially development aid receipts and remittances).

Table 5: Population growth, migration, and poverty, Pacific island countries

Country	Population mid-year 2010	Population mid-year 2050	Crude birth rate (%) (2010)	Population growth rate (%) (2010)	Crude net migration rate (%) (2010)	Last intercensal annual growth rate (urban, %)	Last intercensal annual growth rate (rural, %)	% urban at last census (2010)	% population below basic needs poverty line (baseline year)	% population below basic needs poverty line (latest year)
Melanesia										
Fiji	847,000	1,060,000	20.77	0.46	-7.67	1.5	-0.1	51	25.5 (1996)	34.3 (2003)
Papua New Guinea	6,745,000	13,270,000	30.89	2.13	0	2.8	2.7	13	24.0 (1996)	39.6 (2002)
Solomon Islands	550,000	1,246,000	34.31	2.69	0	4.2	2.5	16	NA	22.7 (2006)
Timor-Leste	1,171,000	3,217,000	25.93	2.00	0	NA	NA	27 [a]	41.5 (1996)	49.9 (2007)
Vanuatu	245,000	539,000	30.89	2.54	0	3.6	1.9	24	26.0 (1998)	15.9 (2006)[a]
Larger Polynesian Countries										
Samoa	183,000	210,000	24.77	0.30	-16.68	-0.6	0.7	21	15.0 (1997)	20.3 (2002)
Tonga	103,000	123,000	26.51	0.33	-16.58	0.6	0.4	23	NA	22.3 (2002)
Micro States										
Cook Islands	15,600	16,000	16.83	0.32	-6.3	2.6	-1.4	72	NA	28.4 (2006)
Fed. States of Micronesia	111,000	137,600	27.76	1.85	-1	-2.2	1.0	22	27.9 (1998)	29.9 (2005)
Kiribati	101,000	163,300	24.3	0.42	-14.69	1.9	1.8	44	NA	21.8 (2006)[a]
Marshall Islands	54,000	61,200	31.14	0.69	-18.43	1.6	1.3	65	NA	20.0 (1999)
Nauru	10,000	16,300	29.75	2.08	0	-2.2	NA	100	NA	NA
Niue	1,500	1,300	13.63		0	-1.1	-2.34	36	NA	13.0 (2004)
Palau	20,600	22,000	22.88	0.59	-8.78	-0.01	3.9	77	NA	24.9 (2006)
Tuvalu	11,000	13,900	NA	0.51	NA	1.4	-0.2	47	24.4 (1994)	21.2 (2006)[a]

Sources: WHO;[109] Population other countries: PRISM;[110] Poverty: Various sources in Table 2, Annex 2 in AusAID. 2009.[111]. [a] Recent HIES data show poverty increasing in Tuvalu and Vanuatu; Greg Keeble, SPC, personal communication; .

Table 6: Annual per capita fish consumption (%) from subsistence fishing and purchases, and contribution of food production to household income (%), Pacific island countries

Country	Annual Per Capita Fish Consumption (%)						Subsis-tence production as % of household income	Sales of own produce as % of income	Range of contribu-tion of home production (subsis-tence and sales) to income (%)
	National		Urban		Rural				
	Subsist-ence	Purch-ased	Subsist-ence	Purch-ased	Subsist-ence	Purch-ased			
Melanesia									
Fiji	35	65	7	93	52	48	NA	NA	NA
PNG	NA	NA	NA	NA	64	36	NA	NA	NA
Solomon Islands	64	36	13	87	73	27	37	6	7-71
Timor-Leste	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanuatu	51	49	17	83	60	40	NA	NA	NA
Larger Polynesian Countries									
Samoa	44	56	21	79	47	53	26	3	7-42
Tonga	37	63	NA	NA	NA	NA	17	14	14-36
Micro States									
Cook Islands	51	49	27	73	76	24	NA	NA	NA
Fed. States of Micronesia	74	26	73	27	77	23	23	NA	15-36
Kiribati	63	37	46	54	79	21	21	11	19-50
Marshall Islands									
Nauru	63	34	NA	NA	NA	NA	NA	NA	NA
Niue	56	44	NA	NA	NA	NA	NA	NA	NA
Palau	47	53	35	65	60	40	3	NA	NA
Tuvalu	77	23	56	44	86	14	55	2	30-65

Note: Values determined from household income and expenditure surveys; NA = no available data.
Sources: Fish Consumption: Bell et al. 2009; Contribution to income: McGregor et al. 2008102

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Part 2: Challenge of climate change for food security

As identified in the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report, the Pacific Island countries (and territories) are highly vulnerable to the projected impacts of climate change. Climate change is expected to affect all areas of development and livelihood, from subsistence food production for food security in villages and rural communities to industries and commercial development in towns and cities. It will affect oceans, land and forest resources that are important sources of livelihood and economic activity for the majority of Pacific Island populations. It will also have an impact on the social, cultural, spiritual, economic, human rights and political landscapes of island countries. It will lead to changes in the international supply and delivery of food to island nations. These expected changes are likely to have profound implications for food security in the region.

Section 7. Climate Change

Climate in the Pacific has changed in the last few decades. Observed changes include increases in annual ocean and land surface temperatures of 0.6 to 1.0 °C since 1910.[1] The southwest Pacific has become drier while the central equatorial Pacific is receiving more rainfall. Projections indicate that these climate trends are likely to continue over coming decades. Observed mean sea-level rise has varied across the region but most countries have experienced rises of 4–10 cm since 1990.

The region is already subject to significant annual and decadal variability in temperatures and rainfall due to the ENSO (El Niño/La Niña-Southern Oscillation) cycle and longer-term regional climatic cycles. In the next 15–25 years the ENSO cycle is expected to remain the most dominant influence on the region's climate and food production, after which the climate change signal is expected to become more pronounced.

Projected changes

There is still considerable uncertainty about the extent of climate change in the Pacific over the next 50–100 years. While some country projections have been produced, there is, in general, a lack of detailed country-specific information. Most projections are based on the lower-resolution climate models used in the 2007 IPCC report.[2,3] However, recent scientific research and regional modelling, including downscaling, is becoming available, which will allow more detailed projections of future climate change and its impacts. In particular, the research results from the Pacific Climate Change Science Program (due to be released in late 2011) are expected to enable better country-level estimates of the timing and magnitude of potential changes.

Based on current projections, key changes are summarised below. It should be noted that changes in climate are expected to vary significantly across the region, and even within some countries.

Atmospheric carbon dioxide: There is projected to be a continued increase in atmospheric concentrations of carbon dioxide (CO_2) over at least the next 30 years. CO_2 concentrations are currently at 390 parts per million (ppm) and, under some high emission scenarios, could reach levels exceeding 600 ppm or more before the end of the century. Much depends on the global community's success in reducing greenhouse gas emissions. Changes in agricultural production due to additional CO_2 may lead to net increases in yields of some crops. The nutritional value of some crops declines as CO_2 concentrations rise and some plants (e.g. cassava) generate higher levels of toxic cyanide as CO_2 concentrations rise.

Rainfall: In general the region is projected to become wetter in the central equatorial and northeast Pacific and possibly drier in the southwest Pacific. However, modelling results exhibit significant variation over the period to 2050 and even the direction of change is uncertain for some areas. The IPCC gives ranges of increases in precipitation (percentage change) in the south Pacific relative to 1961–1990 levels of -3.9 to +3.4

(2010–2039), -8.23 to +6.7 (2040–2069), and -14.0 to +14.6 (2070–2099). More rainfall during summer is projected with an increase in daily rainfall intensity, indicating more frequent and heavier rainfall events.[4] The frequency and intensity of drought are also expected to rise, especially in the southwest Pacific.

Surface air temperature: Average mean surface temperatures in the Pacific are expected to continue the strong underlying warming trend experienced in recent decades (0.2°C per decade) and could possibly accelerate, depending on future global emission trends. IPCC projections to 2050 indicate a likely mean surface air temperature rise for the Pacific of 1.5–2.5°C by 2050 and, under high emission scenarios, up to 4°C by 2100, or possibly higher. The global mean minimum (night) temperature has increased at twice the rate of daytime maximum temperatures during the period from 1950 to 2000 (IPCC 2001).

Ocean surface temperatures are expected to warm at a similar rate. The frequency of days exceeding the average maximum daily temperature is also expected to rise. Ecosystems particularly sensitive to increasing temperatures include coral reefs and mangrove areas. For example, mangrove coverage is expected to decline by 1% and 13% associated with an increase of 2°C and 4°C temperature increase, respectively.[5]

Sea surface temperature and acidification of the ocean: The tropical Pacific Ocean is warming; average sea surface temperature (SST) has increased by 0.7°C over the past 100 years, and is projected to increase by 0.5–1.0°C by 2035 and 2.5–3.0°C by 2100 under continued high emissions scenarios. The oceans are also absorbing around one quarter of anthropogenic CO_2 emissions released to the atmosphere and are becoming more acidic. Ocean pH has already decreased by 0.1 pH units over the past century and is projected to fall by another 0.3–0.4 pH units this century. The changes in SST and pH are expected to have profound effects on the coral reefs that support coastal fisheries production in Pacific Island countries, and for marine fisheries species that depend on carbonates to form their skeletons and shells.[6]

Extreme weather events: An increase in the incidence and severity of extreme weather-related disasters has already been observed and ten of the 15 most extreme weather- events reported in the Pacific over the 50 years to 2005 occurred since 1990.[7] The intensity and frequency of precipitation, flood events (and associated erosion and landslides) and droughts are expected to increase. While tropical cyclones are also expected to increase in intensity, their frequency might not increase, and could even decline.

Flooded taro fields after cyclones, 2005, Cook Islands

***Sea-level rise*:** IPCC projections suggest that global mean sea levels could rise by 0.18–0.58 metres by 2090–2099 relative to 1980–1999. However, it is now widely considered that sea-level rise could be greater than the most recent IPCC estimate (as ice sheet melting was not included) and may exceed 1 metre by 2100. It is difficult to estimate the potential impacts of sea-level rise on food production and there will be significant variation across the region. For example, a one-metre rise could affect as much as 80% of land on Majuro atoll in the Marshall Islands and 12.5% of all land in Kiribati, but much less in other countries. While potentially significant in the longer term, sea-level rise is not expected to have a significant impact on regional food production before 2050, except in low-lying atolls and coastal areas. Changes in the level of the freshwater water table, or salinisation of existing water supplies, can also result from changing sea levels, even if land is not lost. Changes in rainfall may exacerbate the sea-level rise impacts on the water table.

Impacts

Given the limited availability of data and analysis of the expected impacts of climate change on the Pacific region, it is difficult to be definite about the precise costs and impacts, though several studies have produced estimates of the future costs of climate change impacts for certain sectors. For example, the IPCC 2007 report indicates that a 10% reduction in average rainfall by 2050 could mean 20% reduction in the size of the

freshwater lens on some atoll countries. Another study estimates that, region-wide, a 30–50 cm sea-level rise could have direct costs to coastal communities of about USD 1.4 billion per year.[8] The World Bank estimates that, by 2050, annual losses from climate change could cost Tarawa atoll in Kiribati USD8–16 million, or 17–34% of current GDP.[9]

More detailed research, impact assessment and analysis are required, including a better understanding of adaptive capacity and ecosystem resilience, before more robust impact cost estimates can be derived. Nonetheless, based on the current understanding of projected future climate change, it is clear that the Pacific Islands region is likely to experience potentially significant adverse socioeconomic outcomes and that these costs will grow over time.

Section 8. Implications of climate change for food security and related knowledge gaps

Impacts of climate change

Climate change will affect food production all along the food supply chain. Changes in temperature and rainfall regimes (about 70% of the Pacific's agricultural area is heavily dependent on seasonal rainfall[10]), alterations to average and peak temperatures, loss of genetic resources and agro-biodiversity, increased salinisation, more intense weather-related natural disasters, and changes in disease and pest regimes could all have significant repercussions for agricultural production.

Losses from previous, major, weather-related natural disasters in particular have been significant, ranging from 40% to 100% of crops. Almost all of the islands in the Pacific sustained crop damage and loss of both food and cash crops during the drought following the 1997/98 ENSO (Appendix Table 2). In Niue, food aid was needed for several years after major weather events (cyclone Ofa in 1990 and cyclone Heta in 2004).

Under most climate change projections, the intensity of extreme weather events will increase, as will the frequency (except possibly tropical cyclones). This will undoubtedly increase the risks of crop losses and food production losses. However, the extent to which these losses manifest themselves will depend on the adaptation responses and risk reduction measures put in place across the food production system.

Considerable uncertainty remains, however, regarding the quantitative impacts of climate change on regional terrestrial food production, given the uncertainties of future climates; the responses of crop, livestock, disease and pest organisms to these climates; and the many 'micro' climatic conditions within each country. The understanding of potential changes in the fisheries and aquaculture sector is better, as a result of the recent vulnerability assessments made for oceanic, coastal and freshwater fisheries, and for aquaculture production.[11]

A. Ecosystems and preharvest conditions

In this subsection, crop production, livestock and fisheries are discussed separately, as there is a range of forces at work in each sector.

Crop production

Little is presently known about the implications of higher CO_2 levels for regional agricultural production. Wetter conditions would benefit crops such as coconut, breadfruit and cassava, whereas a decline in rainfall would affect most crops, especially the traditional foods, such as yam and taro. Rainfall reduction in a typical strong El Niño event in Samoa results in a loss of 5–8% of taro production and an increase of 3–5%

in the cost of food imports.[12] Drought in El Niño conditions in Viti Levu, Fiji, if drier conditions prevail in future, could lower sugar production by 50% and taro, yam and cassava yields by 11–15%.[13] During the 1997/98 El Niño event, losses of sugarcane in Fiji were estimated at USD52 million.[14]

Extreme events place demands on access to and availability of planting material, which can create difficulties, depending on the planting material network in the country; soil preparation for replanting and nutritional status will also be affected. Lack of rainfall can be a serious constraint to plant establishment as experienced in Samoa with taro.

Changes in the time of fruiting of certain species have been reported; for example, breadfruit, mango and citrus, are fruiting over an extended period and/or are showing shifts in the fruiting season. In the Torres Group (Vanuatu) yams planted in the normal planting season are reported to be no longer performing well.[15] Changes in weather patterns are likely to mean that farmers will have to reconsider planting seasons.

An increase in the minimum temperature could affect the spread of the taro leaf blight disease which, in 1993, destroyed taro cultivation in Samoa. The impact of a warmer night temperature will enable sporulation at night, increasing the incidence of the disease. Countries such as Fiji, Tonga and Cook Islands are all vulnerable to the disease due to the susceptibility of their taro varieties.

Coffee, an important export crop, is sensitive to climate change. In Latin America, modeling has shown that the ideal altitudes for growing coffee will shift and farmers will either need to move to higher areas or consider planting the hardier robusta varieties instead of the arabica varieties as grown in PNG. Similar effects to those experienced in Latin America could occur in Pacific coffee-growing countries. Cocoa is highly sensitive to changes in hours of sun, water availability, soil conditions and temperature.

Atolls require special mention as environments where crop growth depends on groundwater reserves. A recent SPC study[16] found changes in the salinity levels of swamp taro pits in Tuvalu. Palau has reported that taro production is being affected by increasing salinity. Drier conditions can also have a serious impact on other atoll crops, especially coconut and breadfruit.

Tropical forests, important sources of wild food and income from timber and nontimber crops, are particularly climate-sensitive. Even small changes can affect timing and intensity of flowering and seeding, with negative impacts on biodiversity and ecosystem services and increasing risk of species extinction.[17]

Predicted climate changes (generally warmer and wetter for many countries) are likely to increase the prevalence and geographic range of pest and disease outbreaks. Recent surveys in Fiji and Bougainville, conducted by the Plant Health group of the SPC Land Resources Division[18] have confirmed that Black Cross and Black Sigatoka diseases of banana have extended their altitudinal range from 1,200 metres to 1,800 metres. In addition, localised epidemics of anthracnose disease of breadfruit and yam have occurred in wet weather in a number of countries. High infestations of sap-feeding arthropods (aphids, etc.) causing crop damage have been reported in the Yasawa Islands (Fiji).[19] Increases in the prevalence of insect pests capable of transmitting viruses would also reduce crop yield.

Livestock

Health, productivity, and reproductive efficiency of livestock are affected by elevated temperatures. In particular, the increasingly important poultry industry in many Pacific countries is highly vulnerable to increased temperature extremes. Chickens are known to be susceptible to heat stress, dehydration, and reduced productivity under elevated temperatures. Poultry mortality can also be high during floods that inundate production facilities.

The cattle industry is mainly concentrated in the larger islands in the southwest Pacific (Fiji and Vanuatu). Cattle-growing regions in these countries are projected to experience reduced rainfall over the coming decades, with increasing incidence of drought. Overgrazing in drier conditions may increase soil loss and

reduce land productivity and pasture quality. Where increased precipitation (and carbon dioxide) is projected, improved pasture growth would support the establishment of less desirable and less nutritive pasture species that may dominate and replace desired species over time, lowering production. Wetter and warmer conditions would encourage growth and spread of pests and diseases that can endanger animal health and growth, such as increases in intestinal problems in cattle in Vanuatu, believed to be associated with pasture feed.[20]

Saltwater intrusion and land inundation will affect the quality and availability of water supplies. Animal waste contamination of water supplies is of concern because of the potential for the spread of zoonotic disease and the eutrophication of water from increases in nutrient levels.

Fisheries production

Due to the direct effects of global warming and ocean acidification on fish and invertebrate species, and the indirect effects on their habitats (coral reefs, mangroves, seagrasses and intertidal flats), coastal fisheries catches are likely to decrease by 20% by 2050 and by 20–50% by 2100 under continued high emission scenarios.[21] When the projected effects of climate change and population growth on availability of fish per capita are combined, only Cook Islands, Marshall Islands and Palau will be able to supply sufficient quantities of coastal fish to meet nutritional demand in the second half of the century. Five other countries could potentially access sufficient fish if infrastructure and distribution systems are put in place, while the other seven countries will have a deficit in coastal fish production, i.e. be unable to supply enough fish to meet half the protein needs of their populations by 2100 (Appendix Table 3).

In the economically important offshore fisheries, catches of skipjack, the most abundant tuna species, are expected to increase in the medium term (2035) by nearly 20% relative to catches between 1980 and 2000, but may suffer a net loss in the second half of the century, depending on the extent of climate change, including acidification. Preliminary modelling indicates that the major tuna fishing grounds are expected to move to the east, decreasing catches in Melanesia but increasing skipjack catches in Polynesia and parts of Micronesia by nearly 40% in the medium term. By the end of the century the outlook is much less certain and could show a marginal increase or a decline, depending on the extent of climate change (Appendix Table 4). Bigeye tuna, already overfished, are likely to become less abundant everywhere due to climate change. The modelling has yet to be done for yellowfin tuna, although the patterns are expected to be similar to those for skipjack tuna.

Given relatively abundant available tuna resources, the growing gap between population size (fish demand) and projected coastal fish production can potentially be met by increased domestic consumption of tuna. This would require a reallocation of tuna from industrial tuna purse-seine and long-lining export operations, along with increased domestic use of by-catch.[22] For example, in Solomon Islands, which has had average recent tuna catches of 112,000 tonnes per year, 8% of the tuna catch would be needed to provide the population with a total fish availability of 35 kg/person/year by 2035, increasing to 17% of the catch by 2050.[23]

Higher rainfall may result in productivity increases for freshwater fisheries in PNG, Fiji and Solomon Islands. Farming of freshwater fish like tilapia could also benefit from both increased freshwater availability and higher growth temperatures. The overall impact could be a net gain in freshwater fisheries in the medium term. However, the quantities of fish involved will make only modest contributions to filling the emerging gap in fish supplies in these countries, compared to providing better access to tuna for this purpose.

Table 7a summarises potential effects along the agriculture supply chain up to the harvest stage and Table 7b does the same for the fisheries supply chain. Possible adaptation measures are also described.

Table 7a: Potential effects of climate change on the agriculture supply chain and possible adaptation mechanisms

Possible climate change effect	Possible adaptation response
Ecosystems	
▶ Habitats altered due to precipitation and temperature changes, loss due to inundation and salinisation, ▶ Loss of plant and animal genetic resources and livestock breeds before they can adapt to the changing environment ▶ Loss of forest species that are important wild food sources ▶ Spread of invasive species and introduction of new ones ▶ Displacement of native species, altering agro-ecosystems. (Local wild /feral animal species lost due to food scarcity and altered habitats)	▶ Replant and protect catchment vegetation ▶ Undertake groundwater protection measures; maintain natural flooding regimes to replenish water tables. ▶ Initiate invasive species management programmes; strict quarantine; assign roles for monitoring and reporting outbreaks
Preharvest conditions	
▶ Reduced crop production due to (i) flooding and/or salinisation; (ii) heat stress on some plants, affecting growth and reproduction; (iii) damage to crops, forest trees, etc. from wind, salt spray, storm surges ▶ Some crops may benefit from CO_2 fertilisation and some may change in nutrient value and toxicity ▶ Reduced livestock and livestock products (meat, eggs, milk) due to (i) heat stress and extreme weather events affecting growth and reproduction; (ii) impacts on pasture and fodder species; (iii) impacts on other sources of animal feed ▶ Some loss of low-lying arable land due to future sea-level rise in atolls and low-lying areas of larger islands ▶ Reduced land productivity due to increased soil erosion ▶ Water shortages for agriculture and aquaculture in some countries—drying of streams and ponds, soil moisture stress ▶ Slower recharge of water lenses in some atolls ▶ Pollution of groundwater sources/wells from excessive run-off and inappropriate waste disposal ▶ Substantial increases in risk of fire during drought in larger islands; can destroy crops, local animal species, forests and agricultural infrastructure ▶ Growing demand for livestock and livestock products could have significant effects on resources (e.g. land, water, forest, feed, etc.) and increase waste management problems ▶ Overgrazing due to less pasture feed availability and overstocking may result in erosion and weed invasion ▶ High livestock and human densities could increase the threat of zoonotic diseases outbreaks. ▶ Increased incidence of existing pests and diseases and changing behaviours of insect vectors in livestock ▶ Growth of less desirable and nutritious pasture species	▶ Identify and make available climate resilient crop and livestock breeds ▶ Expand the genetic diversity of crops through introductions of traditional and 'new' crops (clonal and seed) ▶ Strengthen crop and livestock breeding capacity ▶ Improve participatory approaches to crop and livestock management (including breeding and pest and disease identification) ▶ Use livestock that requires less land, such as poultry, and species more resilient to specific climate variables ▶ Evaluate and identify optimum pasture species for projected climate change to encourage non-selective consumption of pasture species ▶ Develop local animal feeds that are resilient to projected climate change ▶ Develop animal waste management systems that use waste (biogas) and eliminate associated risks ▶ Improve soil health through building organic matter content no/low-till practices, use of mulches and increased composting/crop residue retention ▶ Increased use of agro-forestry systems to support dynamic and healthy food production systems. ▶ Introduce native vegetation, especially around watercourses, to reduce soil loss and sedimentation ▶ Construct irrigation facilities and distribution networks combined with improved water sector governance and efficiency measures ▶ Increase rainwater harvesting, and access to irrigation by farmers individual households ▶ Strengthen biosecurity, disease surveillance, and emergency response capacity to protect both animal and human health ▶ Protect coastal agricultural land and implement measures to reduce risk of land loss and/or degradation

Table 7a: Potential effects of climate change on the agriculture supply chain and possible adaptation mechanisms (contd)

Possible climate change effect	Possible adaptation response
Harvest stage	
▶ Fields may become inaccessible at harvest time due to transport disruptions ▶ Markets may become inaccessible and crops wasted due to transport disruptions ▶ Increased risk of crop spoilage due to temperature and humidity effects ▶ Changes in crop ripening times ▶ Changes in fruiting seasons ▶ Increased mortality during transporting and movement of livestock to slaughter houses due to high temperature and other extreme weather events. ▶ Increased poor animal welfare practices as a result of extreme weather events.	▶ Adjust cropping systems and schedules to avoid harvest periods coinciding with periods of high risk of flooding ▶ Use food production systems less at risk from extreme events ▶ Enhance climate resilience of transport infrastructure, e.g. culverts, stronger road surfaces, moving routes to higher or more protected sites, emergency response capabilities ▶ Improve response systems for extreme weather events

Table 7b: Potential effects of climate change on the fisheries supply chain and possible adaptation responses

Possible climate change effect	Possible adaptation response
Ecosystems	
▶ Reef ecosystems negatively affected by all changes—higher temperatures cause mortality in some coral species due to loss of photosynthetic symbionts; oceanic acidification reduces ability of corals and other calcium-shelled organisms to form skeletal material; sea-level rise reduces light penetration, which may cause extirpation of deeper and slow-growing corals; higher rainfall and cyclones lower salinity and light from flood run-off, and physical damage. ▶ Changes to coastal current patterns, sea surface temperature and salinity, cause increased stratification of the water column, affecting nutrient supply and fish production ▶ Potential increases in habitats for freshwater fisheries, mainly in PNG, Fiji and Solomon Islands	▶ Manage catchments to increase vegetation cover to reduce transport of sediments, nutrients and chemical pollution to coral reefs, mangroves and seagrasses, thereby maintaining their natural capacity to adapt to the stresses associated with climate change. Improved catchment management will also enable potential gains to freshwater habitats to be harnessed. ▶ (None possible for open ocean fish habitats)
Preharvest conditions	
▶ Reduced productivity of coastal fish stocks due to damage to coral reef, mangrove and seagrass habitats and ocean acidification ▶ Possible increase of ciguatera fish poisoning due to elevated temperatures, especially in Tuvalu, Cook Islands, Kiribati, and Samoa ▶ Changes in the distribution of fish stocks, taking some stocks out of local fishers' range ▶ Offshore tuna stocks move eastward, catches decrease in the west, but increase in the east. ▶ Increases in production of freshwater fisheries in PNG, Fiji and Solomon Islands ▶ Increases in the areas where tilapia can be produced in pond aquaculture due to increases in temperature and rainfall	▶ Protect coastal fish habitats (coral reefs, mangroves, seagrasses and intertidal flats) from local stressors to maximise their natural resilience to climate change ▶ Provide for landward migration of mangroves, and replant trees where needed ▶ Foster sustainable 'primary' fisheries management for coastal and freshwater fisheries ▶ Implement responsible aquaculture in growth areas

Table 7b: Potential effects of climate change on the fisheries supply chain and possible adaptation responses (contd)

Possible climate change effect	Possible adaptation response
Harvest stage	
▶ Changes in species composition of demersal fish catches associated with coral reefs ▶ Change in relative harvests of tuna among countries, with possible impacts on cannery supplies ▶ Increases in overall industrial tuna catch in the medium term, with projected net losses for the western side of the region post 2050 ▶ Extreme weather may restrict fishing days and increase boat damage ▶ Fishers need to travel further; need larger vessels; use more fuel	▶ Diversify coastal fish catches e.g., tuna around inshore fish aggregating devices; harvesting small pelagics ▶ Store, process and distribute low-value tuna and bycatch landed at major ports ▶ Revise management regimes for tuna ▶ Develop peri-urban and rural pond aquaculture ▶ Improve access to canned tuna ▶ Strengthen safety at sea regulations

B. Postharvest economic, health and social conditions

Postharvest quality can be affected by climate change prior to harvest. For example, temperature increases can cause changes in sugar, firmness and antioxidant activity, and increases in carbon dioxide can cause tuber malformation and the occurrence of common scab on potatoes.[24] Delays in harvesting mature crops due to unfavourable weather can promote the development of rot. Storing crops in poor condition, under too high temperatures, encourages storage rot and further damages quality.

Food storage, processing and transport facilities, already weak links in the food chain, may be damaged. Such disruptions will translate into higher prices and produce scarcity in markets. The downstream effects will be felt not only by local consumers but also in export markets. More food will have to be imported, resulting in greater trade deficits, and the likelihood of increased health problems. Poor health can have an adverse impact on food production potential through reduced worker productivity (lost work days) and affects the capacity of women in their domestic roles, especially home food production and preparation. It will also drain health budgets and divert resources from other priority development needs.

An increase in the incidence of malaria[25] and dengue[26] is expected. Flooding and contamination of surface water with sewage can spread water-borne diseases, such as typhoid, shigella, and hepatitis A and E. Drought can lead to increased concentrations of pathogens in surface water and increased illness and death from a combination of diarrhoea and dehydration.[27] Reduced nutrition availability can impact on child learning and education outcomes, and thus future income earning potential. There are also likely to be other effects of increased temperature and humidity levels, including greater food contamination effects, higher incidence of plant-based allergens, and an increased incidence of fungal diseases. These conditions also reduce food security directly by affecting food utilisation and food safety. Further, the likelihood that more food per capita will be imported may increase the prevalence of non-communicable diseases.

Loss or degradation of land can precipitate greater rural-urban migration, creating greater dependence on food markets and local fish stocks, increasing environmental pollution and reducing freshwater quality and quantity.

Rural livelihoods are vulnerable to climate-related hazards in the Pacific, not only because of land degradation and loss of labour to towns, but also due to poor infrastructure and weakening of traditional social networks.[28] Poverty is likely to increase further if current economic trends persist. Women in particular will be affected by declines in intertidal gleaning areas as sources of household protein and by loss of employment in a diminished food sector.

Table 8 summarises possible climate change effects at the postharvest stage, including the effects on infrastructure, the economy, social structures and health of Pacific populations. Adaptation responses are suggested.

Table 8: Climate change effects at the postharvest stage and possible adaptation mechanisms

Possible climate change effect	Possible adaptation response
Infrastructure	
▶ Destruction of agriculture infrastructure: farm shelters, storage facilities, drainage systems, from storm events and floods ▶ Cannery operations disrupted ▶ Loss of transport access, processing and storage due to damage to energy-related infrastructure, ▶ Damage to roads, especially coastal, due to storms but also internal due to landslides, etc., preventing distribution of produce ▶ Disruption of ocean transport and port facilities	▶ Improve food storage methods and preservation facilities, including emergency food stockpiles ▶ Increase climate resilience of food marketing and distribution facilities (including fresh food markets, refrigeration facilities and stock monitoring) ▶ Improve knowledge of postharvest pests and diseases ▶ Increase use of crop and livestock diversity to respond to need for postharvest resilience
Markets	
▶ Prices of local produce driven up if scarcer ▶ Increasing dependence on imported food sources ▶ Possible loss of markets due to presence of new diseases in production system ▶ Higher product costs due to need to address biosecurity concerns for new diseases/pests	▶ Safe storage of fish products (freezer and cool room facilities) to ensure adequate supplies during adverse sea conditions; stronger vessels and improved services; climate resilient shore infrastructure (piers, docks and storage facilities) ▶ Investigate methods of better, longer storage ▶ Foster intraregional trade of traditional, nutritious crop products to support local produce supply
Trade	
▶ Increasing trade deficit if food production for domestic use and exports decreases, and need for imported foods increases	▶ Boost local food production, especially fish (fishing and aquaculture) and non-land-intensive livestock, such as poultry for export as well as domestic use ▶ Cross-subsidisation using revenue from taxes or duties on unhealthy products ▶ Higher tariffs on imports of unhealthy foods, (as already done to some extent in the Cook Islands, Fiji, PNG and Samoa)
Economic competitiveness	
▶ Potential GDP losses through reduced agricultural productivity and coastal fisheries; increased burden of food imports, loss in work days due to increased morbidly/mortality from climate-related weather events and health impacts	▶ Support and revitalise local food production systems with a special focus on value adding and processing to enable the production of cost-competitive food products, using sustainable modern and traditional methods, and to enhance farm incomes

Table 8: Climate change effects at the postharvest stage and possible adaptation mechanisms (contd)

Possible climate change effect	Possible adaptation response
Livelihoods, urbanisation and poverty	
▶ Decreasing rural employment due to loss of productive land and associated accelerated rural-urban migration ▶ Increasing urban unemployment due to higher influx, mainly youth, from rural areas ▶ Increasing consumption of highly processed foods associated with higher urban populations ▶ Potential for increased incidence of hunger and poverty	▶ Investigate ways to improve land tenure systems and land-use/access policies ▶ Promote and support small-scale agriculture and local processing enterprises ▶ Exploit opportunities for domestic and export freshwater products, including aquaculture ▶ Encourage fishing for inshore pelagic fish to supply local and urban markets ▶ Greater focus on stimulating local food subsistence production and small enterprises to add value (e.g. egg processing) ▶ Seasonal or long-term migration where possible to neighbouring countries (to generate remittances for countries that will continue to rely mainly in imported food) ▶ Greater focus on measures to address population growth rates ▶ Measures to improve rural development, such as enhanced, climate-proofed rural development plans and measures to encourage a return to the land
Health	
▶ Potential nutrition-related increases in morbidity/mortality and potential increased dependence on processed foods ▶ Increasing health expenditure burden ▶ Emergence/re-emergence of infectious diseases, including zoonotic ones	▶ More robust food safety laws, regulations and enforcement strategies to improve food hygiene and food quality ▶ Awareness campaigns, education, mobilising communities and groups (such as through the Pacific Youth Strategy) concerning nutrition and dietary preferences ▶ Nutrient fortification to address micronutrient deficiencies that cannot be solved through local food sources
Gender	
▶ Loss of women's employment in postharvest sector, mainly as processors and vendors if supplies disrupted or production falls ▶ Gender issues from changes in coastal fisheries (impacts men and women differently) and intertidal areas (women) ▶ Malnourishment affecting family well-being, which can affect household roles ▶ Reduced capacity of women in performing roles as primary health carers, food preparers, etc. ▶ Increased burden on women if they are to manage emerging issues in food production and family health	▶ Development of women's cooperatives and micro-finance opportunities ▶ Education programmes aimed at improving knowledge in such areas as nutrition, human health, food processing and storage, indigenous medicinal herb production ▶ Strengthened gender support programmes to help men and women adjust to climate-induced changes to food production systems ▶ Increasing support for lactating women (e.g. education, supply of equipment, nutrient supplements) to improve child nutrition
General	
	▶ Enhanced regional food security research capabilities and information dissemination and networking between existing national and regional institutions ▶ Revise primary and secondary school curricula to teach children about nutrition and healthy diets ▶ Foster exchange on best practices from adaptation activities in the Pacific and other similar regions that can be replicated in the Pacific

Knowledge gaps

Potential adaptation responses to some emerging issues are summarised in Tables 7a, 7b and 8. However, in many cases, there is inadequate knowledge and information to identify appropriate adaptive measures at this stage. If the region is to accommodate the impacts of climate change effectively through appropriate adaptation measures, the knowledge base must be improved and strengthened. Actions to address major knowledge gaps are summarised below.

Preharvest conditions

Crop production

- Applied research on the resilience of existing crop production systems (including crop diversity) to specific changes in climatic variables, and the evaluation of innovative farm management techniques incorporating new crop varieties in different agro-economic systems.
- Systematic evaluation of Pacific crop varieties for their resilience to climatic change (e.g. physiological thresholds), especially in terms of compatibility with existing farm systems, impact on yields and farm incomes, palatability and market acceptance.
- Assessing the potential changes to agro-biodiversity (especially soil biodiversity, pollinators and pest predators) and how these may affect yields of different crops due to projected changes in key climatic variables.
- Improved understanding of climate-induced changes to pest and disease regimes and the role of strengthened integrated pest and disease management approaches at the farm level, especially for subsistence agriculture.
- Evaluation of the contribution of farm agro-forestry and intercropping techniques on food production resilience.
- Improved understanding of the impact of climate change (temperature, seasonal and annual precipitation, susceptibility to changed flood regimes) on commercial cash crops (for example, copra, cocoa, sugar, coffee, rice, ginger) and identification of measures that could ameliorate these impacts.
- Understanding of the potential changes to nutrition levels, toxicity and yields of Pacific subsistence and cash crops, including pasture, under elevated carbon dioxide concentrations.
- Evaluating the role of increased use of seed-propagated crops (especially vegetables), based on imported varieties and seed varieties specifically adapted to Pacific Island conditions, as a crop diversification and farm production risk minimisation measure, and the extent such measures could contribute to regional food supplies.
- Cost and benefit studies of increased access to irrigation and water efficiency technologies as a means of reducing dependence on rainfed agriculture.
- Evaluation of animal waste management approaches, including low-cost biogas digesters.
- Assessment of the resilience of existing livestock production systems (including diversity and feeds) to specific changes in climatic variables, and evaluation of innovative farm management techniques incorporating new livestock breeds in different agro-economic systems.
- Potential contribution to domestic food supplies of introduced fish species (such as tilapia) and new livestock varieties that exhibit higher resilience to specific climate variables (especially temperature and water requirements), and an improved understanding of the environmental and biodiversity risks associated with these species.
- Improved understanding of how present environmental problems, over-exploitation of resources and pollution affect the climate resilience of Pacific food production capabilities, and whether payment for ecosystem services and restoration of traditional land-use controls can contribute to increased resilience. For example, the value of ecosystem services of mangroves on Viti Levu, Fiji, is estimated at USD 1,000–2,500 per hectare per year.[29]

Fisheries production

- Development of new fishing technologies to access local tuna resources, particularly in-field demonstration activities to identify the costs and benefits of near-shore fish-aggregation devices to supplement coastal fisheries food supply.
- Understanding of the implications of the projected easterly movement in tuna stocks, requiring modified management and access regimes and approaches that are equitable to all countries.
- Cost-benefit analysis on alternative uses of tuna resources (such as reallocation for domestic consumption and import substitution).
- Similar analysis on the export of coastal demersal fish from fish-deficit countries, and development of new fishing technologies to access local tuna resources.
- Improving the models used to predict the abundance and distribution of the important tuna resources in the tropical Pacific under climate change to fill gaps related to dissolved oxygen levels, water temperature, nutrient supply, ocean acidification[30] and supply and behaviour of tuna prey species.[31]
- Evaluating the potential harvest levels of small pelagic species and the likely effects of higher levels of nutrients from the projected increases in runoff around high islands in Melanesia on the productivity of these species.
- Determining whether there is a link between the risk of ciguatera fish poisoning and climate change.
- Assessing the vulnerability to climate change of deepwater demersal species taken by coastal fisheries, especially snappers and groupers.
- Evaluating potential impacts of Nile tilapia introduced for pond aquaculture on freshwater biodiversity.

Postharvest conditions

- Improved data on existing food chain crop losses due to spoilage during transport and storage, and how these losses may be influenced by changes in temperature and humidity.
- Costs and benefits of improved food storage and distribution infrastructure (such as refrigeration and pest control measures).

Markets, trade, and vulnerability

- Assessment of the potential contribution of increased urban and peri-urban food production to total food supplies, what support measures are needed (technical, education/information dissemination, cultural, urban land-use zoning and tenure regimes), and how climate change will impact on urban and peri-urban agricultural production.
- Trade and local market condition studies, such as on improving local food storage and preservation, improving the attraction of local markets, cost-benefit analyses of offshore fish harvest (re)allocation, and policies to support local food production.
- Understanding the political, cultural and social constraints of countries and communities that influence adaptive capacity, including the implications for current roles of men and women in change decision making[32] and governance, e.g. of fisheries.[33]
- Improved socioeconomic assessment of how climate change will affect rural livelihoods across the region and the potential options for addressing these vulnerabilities to minimise the implications for regional food security.[34]
- Improved understanding of regional political and social dynamics of temporary and permanent climate change-induced displacement and migration and the implications for national and regional food security.
- Assessing the implications of existing international commitments (e.g. trade agreements; law of the sea and maritime boundaries; and multilateral environmental agreements, especially relating to the Convention on Biodiversity) to long-term food security and the adoption of climate change response measures.

Health

- Improved baseline data and systematic monitoring of food consumption and nutrition trends (linked to health statistics) to identify how climate change is influencing Pacific diets and emerging nutrition issues.

Key Trends

The interconnected physical effects of climate change along the food chain will weaken the *availability* and *stability* food security pillars. Socioeconomic and health outcomes of population and urbanisation factors under climate change will weaken the *accessibility* and *utilisation* pillars, while deteriorating local food safety and the need for more imported food may further threaten the final pillar, *safe and nutritious* food.

There are many possible responses to the threats and opportunities of climate change, as shown in Tables 7a, 7b and 8. An integrated response package is required such that changes in one sector do not disadvantage individuals in another. It is important that those adaptation options that can be acted on immediately do not compromise future potential for long-term sustainable food production and livelihoods, even though other adaptation options may require further research and development over a number of years. Potential adaptation responses need to be appraised in terms of their impacts across environmental, economic and social facets of food security systems.

It is important to note that climate change effects will overlay a range of other factors driving food security. In particular, population growth, by increasing pressure to produce more on limited land resources, further reducing fallow periods, converting remaining forests for agriculture and grazing, and increasing overfishing especially near urban areas, will, if not checked, substantially reduce the longer-term potential of increasing food production per capita in many Pacific Island countries over the next 50 years.

Section 9. Regional, national and donor responses

Regional responses

Climate change is an important issue confronting the Pacific region and, over the last decade, has become a major political focus of Pacific leaders. Recent initiatives by the Pacific Islands Forum leaders include the *Pacific Islands Framework for Action on Climate Change, Climate Variability and Sea Level Rise, 2000–2004*; the *Pacific Islands Framework for Action on Climate Change, 2006–2015;* the *Pacific Plan for Strengthening Regional Cooperation and Integration;*[35] and the *2008 Niue Declaration on Climate Change.* At the 41st Pacific Islands Forum, held in August 2010, country leaders endorsed a set of principles to guide their countries and development partners in implementing climate change adaptation and mitigation measures.[36]

In response to these political initiatives, a range of actions is being implemented by regional organisations to assist countries to adapt to climate change and to strengthen regional coordination of climate change action. The Pacific Islands Forum Secretariat (PIFS) is leading the regional political engagement process, including the assessment of future climate change financing options for the Pacific region. The Secretariat for the Pacific Regional Environment Programme (SPREP) has an important regional coordinating role, and both SPREP and SPC implement climate change technical assistance and research support at the national and regional level. Several development partners, especially Australia, the European Community and the Germany, are supporting these initiatives. The University of the South Pacific (USP) and other regional organisations also implement climate change activities and provide technical support and capacity building.

Regional food security and climate change initiatives

Food security issues in the Pacific region have attracted growing political attention in recent years, partially driven by the food price spikes experienced since 2007. A regional framework for action on food security in the Pacific[37] was adopted in 2010. This framework includes a range of measures targeting climate change and food security. The framework recognises that food security involves access to and proper utilisation of land; secure transport services and transport infrastructure; reliable and affordable energy; and information, educational materials and technologies as a means to enhance the economic livelihoods of farmers and rural communities.

The Food Secure Pacific Working Group (FSPWG)[38] has been established to coordinate and develop the framework for action. The group has aligned the food security-related activities of its individual members into a matrix, forming a single joint work plan. The aim of the group's climate change and food security activities is to 'promote and strengthen inter-sectoral collaboration and link community resilience and coping mechanisms to protect against adverse effects of climate change natural disasters.'

Some present and planned activities by regional agencies on the impact of climate change on food security are shown in Appendix Table 6, though the status of some of the activities listed regarding funding and implementation is unclear. SPC is the lead regional technical organisation for agriculture, fisheries and health and has an active programme targeting climate change and food security issues. Actions include a major three-year study on the impact of climate change on Pacific fisheries and aquaculture; developing and screening 'climate-ready' crops through SPC's Centre for Pacific Crops and Trees; adaptive capacity assessments; and studies on sustainable land management, agro-forestry and integrated farm management, agro-biodiversity, and effects on crop yields of elevated CO_2 levels. In support of these activities, SOPAC (the Applied Geoscience and Technology Division of SPC) provides an integrated approach to issues of climate variability and environmental stress to help countries develop their natural resources as well as their capacity building, awareness and advocacy related to water resources and water supply and sanitation services. These also contribute to food security outcomes.

Through the Pacific Adaptation to Climate Change (PACC) project being implemented by SPREP, four countries (Fiji, Palau, PNG and Solomon Islands) are taking measures to improve food security. These include flood risk reduction activities in rural areas (Fiji); enhancing resilience of coastal food production systems (Palau); evaluating drought resilience measures like low input/low technology irrigation systems (PNG); and identification and evaluation of adaptation technologies to reduce crop yield decline, wave overtopping and inundation, demonstration of salt resistant crops and provision of additional food storage facilities (Solomon Islands).

The SPC/Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) regional climate change programme also includes a significant level of support to the agriculture, forestry and fisheries sector. Some activities are under way and more are in the process of being developed with the countries. The regional Aquaculture Action Plan[39] and associated regional aquaculture technical cooperation project (covering 11 countries) has activities related to climate change.[40]

National Responses

At the national level most pacific countries have prepared national climate change strategies and action plans, including adaptation programmes of action, national communications to the United Nations Framework Convention on Climate Change , and a range of other national climate change policy statements and strategies. A number of these focus on food security and relevant projects are shown in Appendix Table 6. The table also shows food security-focused activities submitted to the Adaptation Fund.

Bilateral climate change support to the countries has grown significantly in recent years, especially through assistance from Australia and several multilateral organisations. Many countries have, however, occasionally experienced difficulty in effectively managing and coordinating existing levels of climate technical and financial assistance.

Although there appear to be no climate change-related food security projects in Timor-Leste, there are several externally-funded national projects focusing on food production towards food security or food self-sufficiency, such as *Seeds of Life III,* which continues development of a national seed system towards food security;[41] a European union food security programme, including an ongoing project on building food security and resilience among rural households in Timor-Leste;[42] a UNICEF World Food Programme joint project on children, food security and nutrition;[43] and projects by the Mercy Corps,[44] CARE[45] and the Unitarian Service Committee of Canada.[46]

While progress has been made in linking projects to national plans and strategies, the projects being implemented have often been ad hoc, and not fully integrated into sector development plans and governance arrangements. Climate change integration at the line ministry level (such as agricultural and fisheries departments), is limited in many countries and few have detailed sector-wide climate change adaptation implementation plans, or supporting sector policy and governance arrangements. There is, however, considerable variation in progress across countries. The development of integrated sector-wide climate change strategies in the fisheries and agriculture departments is a priority action area and should be a major focus of climate change technical assistance support in the coming years.

Development partner responses

Bilateral and multilateral agencies are providing regional and/or national climate change-related technical assistance, some of which includes food security elements, although few presently focus exclusively on food issues. Appendix Table 7 shows the range of projects either being implemented or about to be implemented by development partners in the region. However, over the next few years the level of bilateral, multilateral and regional support for climate change activities focusing on food security is set to expand significantly through, for example, the SPC/GIZ programme, the SPC/European Union climate change programme for small island states, the SPREP/UNDP PACC project, the Australian International Climate Change Adaptation Initiative including the Pacific Adaptation Strategies Assistance Programme, the USP/Pacific Europe Network for Science and Technology and several other multilateral (Asian Development Bank , World Bank) support activities. FAO has planned a large six-year Food Security and Sustainable Livelihoods Programme in Pacific Island countries.

There are also increasing numbers of community adaptation projects being implemented by national and international non-governmental organisations (e.g. Oxfam, World Vision, The Nature Conservancy) and the Global Environment Facility Small Grants Programme that target climate and food security. Effective coordination of these external inputs to minimise the drain on limited national capacities will be an important consideration during implementation. At present, a Development Partners on Climate Change group meets informally every few months, joined by implementing agencies (Council of Regional Organisations in the Pacific, United Nations agencies and NGOs) to discuss progress, issues and opportunities.

Section 10. Conclusions and options

The Pacific region is already facing a range of food security problems and, if current food production trends persist, food security is likely to deteriorate even further over the coming decades. This is especially the case in the smaller Pacific Island countries, where the food security outlook is much more precarious than for the larger Melanesian countries. Timor-Leste also faces a range of long-term food security issues.

Although significant uncertainty remains in the timing and magnitude of climate change in the region, overall it is clear that climate change will increase existing risks to food security, especially in relation to increased exposure to extreme weather events in the short term. Many actions and measures can be implemented to increase the region's resilience to climate change in a food security sense. However, the many existing gaps in knowledge of and measures to adapt to climate change outlined earlier demonstrate that considerable research and in-field assessment remain to be done before decision makers can make well-informed decisions on appropriate adaptation responses.

Opportunities exist in many countries to increase domestic agriculture and fisheries production and the report lists many measures that can be taken towards more productive, climate-resilient and sustainable agriculture and fisheries systems, along with improved food processing and storage strategies and related infrastructure, such as small ports and roads for distribution and marketing, which need to be developed or made more resilient to expected future climates.

The measures needed also include improvement in the socioeconomic environment, from land tenure to food security education to governance. Measures need to be taken that will minimise the physical and socioeconomic constraints faced by farmers and fishers to improve food systems and make livelihoods less vulnerable, especially for women. Issues relating to migration and settlement issues and resolution of differences between food security goals and those of various international agreements and conventions also need to be addressed by the region.

Countries that favour, or are obliged by lack of domestic resources to use, imported food supplies to satisfy most of their food demand will have different priorities from those of countries focusing on domestic food production. Significant increases in national income will be required to overcome foreign exchange deficits due to increased food purchases. Increased value-adding in food production systems and strengthening export infrastructure (ports, roads and export-import facilities) for climate resilience will also be required.

From the analysis undertaken in this report it is evident that most Pacific countries will continue to need food imports to meet their domestic requirements, especially in the event of severe natural disasters. Some key responses include developing intraregional food trade, awareness campaigns and education on healthy diets, and filling the considerable knowledge gaps on climate change impacts on food security.

Given existing domestic capacity constraints, considerable external technical and financial assistance will be required for new and ongoing research and development projects by regional and international organisations, supported by national capacity development building. Building national capacities to effectively manage present and future food security will need to remain an important ongoing objective for development partner financial and technical assistance to the region.

Building the capacity of regional institutions in the Pacific to supply specialised scientific and technical support in areas where it is not practical to sustain such expertise at the national level will be a particularly important target area for development partner support. For the medium term, national governments could set up multidisciplinary expert teams within government to coordinate the activities of external agencies and to ensure that the countries' interests are best served, until national capacity to maintain food security is sufficiently developed.

Better regional coordination and alignment of technical assistance flows at the national and regional level remain a high priority. The 2010 *Framework for Action on Food Security in the Pacific* offers a broad framework for improved coordination and harmonisation of food security measures, although development partners must be willing to provide a better integrated package of services, rather than independent delivery mechanisms, to ensure that countries can effectively absorb increased assistance.

Development partners of Pacific countries are now beginning to focus more on food security, including climate change impacts, as the need for increased food supply begins to overshadow previous optimism that world supplies were adequate and only needed more equitable distribution. As ADB recently stated: 'The rapidly dwindling world food stock position will not support such demand over the long term unless sustainable food production and supply augmenting measures are implemented on a war footing. Efforts to stabilize food prices must take center stage. Otherwise, the riots that are occurring in the Middle East and North Africa may spread to other parts of the world.'[47]

The opportunity exists to significantly strengthen the Pacific region's food security position and build its resilience to future climate change impacts. It is also recognised that some countries, especially the smaller atoll countries, will continue to face significant challenges. Effectively responding to the impacts of climate change will be an important consideration in the regional efforts to maintain food security.

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Appendix 1. Land tenure security, population growth and agricultural development – Secretariat of the Pacific Community

Economists tend to agree that clarity and security of land tenure is beneficial in a number of ways. Secure tenure, and the perception of it, optimises farmers' incentives to invest in preserving the productivity of their land. Security enables them to be confident they will reap the rewards in the future instead of having their land appropriated by others or wasting resources on land disputes. Secondly, the maintenance of land productivity associated with land tenure security can help to protect the environment. For instance, maintenance of soil quality reduces the economic incentive a farmer may have to move agricultural cultivation to excessively sloping or forested land, and reduces soil erosion into ecologically fragile environments such as coral reefs. Thirdly, secure tenure can improve likelihood of access to formal credit both through a source of reliable collateral and through higher incomes.[1, 2]

Strong and efficient land governance is required to generate this environment. However, lack of clarity over the terms of both ownership and lease of customary land is widespread in the Pacific, intensified by rapid urbanisation, corruption and lack of technical and administrative capacity in land governance. The effect is that investment in sound land use practice and long-term agricultural productivity are hindered. Lack of leasehold tenure security and potential for dispute also acts as disincentive to foreign investors. The Land Management and Conflict Minimization Synthesis Report[3] elaborates:

> 'There is an apparent disjoint between the notion of group "ownership" in customary land tenure and the Western concept of private property rights that is seen as fundamental to a modern market-based economy. This misalignment has been at the core of less-than-desirable use of customary land for commercial purposes, particularly where customary landowners have not been formally recorded and landownership rights in groups are not accepted by financial institutions.
>
> 'Rural to urban migration and emigration are adding others layers of demands on customary land tenure. Urbanisation and migration have raised the issue of lack of clarity of the rights of members of landowning groups who are away from their land for extended periods of time, as well as the issue of access to customary land for settlement, while ensuring that landowners do not lose their superior rights. Not only do these challenges cause local-level anxiety and disagreement, they can lead to conflicts that are taken to courts. Such conflict resolution processes can be time consuming and affect economic growth.'

Moreover, with population growth, land use has intensified due to land shortage leading to land degradation, land-related conflict and ultimately loss of agricultural productivity. The availability of agricultural land in hectares per capita has been on the decline in most Pacific Island countries; the ratio of agricultural land to agricultural population varied from 7.63 hectares in Samoa to only 0.36 hectares in Solomon Islands in 1994.[4] In most Pacific societies, land resources are the primary basis for subsistence and commercial production, and can also provide a source of subsistence and survival for displaced communities in times of violent conflict, as experience in Solomon Islands has shown. High population growth rates and/or density, displacement of traditional land and resource management systems, introduced agricultural systems, land shortage, land tenure conflict, mining, deforestation and poor development practices have all been noted as being the principle causes of land degradation (Pacific Island Countries – Regional Synopsis on Sustainable Development, 2002).

Questions of clarity over title, resource and customary rights relating to land use were reported as significant drivers for degradation and loss of productivity. Conflict over access and rights to land and resources has also been exacerbated by the transition from traditional farming to cash crops – which require individual entity investment in contrast to family unit holdings.[5]

Under the Tongan constitution of 1875, nobles are allocated land under the constitution and all adult male Tongans are entitled to a plot of land (initially 8.25 acres) for residence and subsistence. This land 'entitlement' is now under threat from an increasing population – in 1996 30% of Tongans were landless.[6] At the same time some landholders have become absentee landlords and are renting out their land, particularly residences in the capital, Nuku'alofa. An attempt to limit succession of land rights to those retaining Tongan citizenship was overruled by the Tongan High Court. There is also mounting objection that some nobles have abused their powers in the allocation of land. Against this background, one of the concerns of the Tongan Pro-Democracy Movement is the question of 'access to land for ordinary Tongans'.[7]

In Tuvalu, intense population increase and heavy in-migration to Funafuti Atoll, on which the national capital is located, have created land shortages and fragmentation of landholdings. This is exacerbated by the fact that over 25% of land has been alienated or leased by government, an unusually high percentage for the Pacific Island countries and territories. People have become reluctant to sell or lease land due to land scarcity, and since the 1980s there has been an increasing incidence of land disputes both between customary landowners and in-migrants, and within families.[8, 9]

Availability of land is also a particular problem in Samoa's national capital, Apia.[10]

Even when the problems of in-migration are less dramatic, as in much of Polynesia and Micronesia, land shortage has added to tensions arising from urbanisation:

> 'Throughout Polynesia a substantial amount of land in urban areas is held under customary tenure and is almost entirely beyond the reach of regulation and management. The relative absence of freehold land is raising costs as new developments are concentrated on expensive plots that are not necessarily the most appropriate….Commissioned reports on key urban development issues in Polynesia rarely omit reference to the need to modernise and reform land management practices but few are prepared to indicate in their recommendations what should be done.'[11]

Notes

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4 Matt McIntyre and Associates 2008. Environmental Causes of Conflict, Land Management and Conflict Minimisation Project, Pacific Islands Forum Secretariat.

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6 Schoeffel, P., 1996. *Sociocultural Issues and Economic Development in the Pacific Islands*. A Report of RETA 5548: Analysis of Sociocultural Characteristics of Economic Systems of PDMCs. Manila: Office of Pacific Operations and Social Development Division, Asian Development Bank.

7 May, R.J. 2008. Review of the Historical Context of Current Land Management and Conflict Management Situations in the Pacific, Land Management and Conflict Minimisation Project, Pacific Islands Forum Secretariat.

8 Leupena, T. and Lutelu, K., 1987. Providing for the multitude, in R. Crocombe (ed.), *Land Tenure in the Atolls. Suva: Institute of Pacific Studies, University of the South Pacific, pp.143-165.*

9 Connell, J. and Lea, J.P. 1995. *Urbanisation in Polynesia*. Pacific Policy Paper 14. Canberra: National Centre for Development Studies, Research School of Pacific and Asian Studies, The Australian National University.

10 May, R.J. 2008. Review of the Historical Context of Current Land Management and Conflict Management Situations in the Pacific, Land Management and Conflict Minimisation Project, Pacific Islands Forum Secretariat

11 Connell, J. and Lea, J.P. 1995. *Urbanisation in Polynesia*. Pacific Policy Paper 14. Canberra: National Centre for Development Studies, Research School of Pacific and Asian Studies, The Australian National University.

Appendix 2. A comparative analysis of food consumption, access, expenditure and income generation in four Pacific Island countries – Secretariat of the Pacific Community

The Public Health and Land Resources Division of the Secretariat of the Pacific Community (SPC) conducted an analysis of food consumption, access, expenditure and income generation in four Pacific countries. The Household and Income Expenditure Survey (HIES) data were analysed for Tuvalu (2004 and 2010), Tonga (2001 and 2009), Vanuatu (2006) and Kiribati (2006). Trend data were only available for two countries (Tuvalu and Tonga) as the other two countries had yet to complete a repeat survey.

The analysis aimed to address key questions on the four themes of food consumption, access, expenditure, and income generation. The following questions are addressed in this paper:

- What foods are consumed and what percentage of the diet do they comprise?
- How has consumption changed over time?
- Which foods have become more or less important?
- How has consumption of own production changed over time?
- What are the food groups that are home produced?
- How much food is purchased?
- What percentage of total expenditure is used to purchase food, has this changed over time?
- What percentage of food expenditure is in cash, in kind and home produced?
- How has the percentage of cash food expenditure changed over time?
- What percentage of food expenditure is spent on imported foods?
- What is the proportion of food expenditure that is composed of gifts?
- What proportion of household income comes from home produce?
- What percentage of household income is generated by agriculture, livestock, and fisheries?
- Which particular crops/species are the most important in terms of income generation?
- What proportion of household income is composed of food gifts?

For each theme, the analysis captured national percentages and the key differences between rural and urban areas. The analysis is presented in graphical form as well as in statistical tables.

This report was prepared using the results from the individual country analysis, and other data available to SPC. The analysis of HIES data was undertaken in country and in collaboration with the national statistical offices. The HIES datasets were made available to SPC staff for the purposes of this analysis.

It should be noted that the survey data are subject to sampling error, and therefore the percentages presented in the report are estimates representing mid-point values. Typically sampling errors for HIES data range from 3-5% for total expenditure estimates to around 15-20% for food expenditure groups.

C1. What foods are consumed and what percentage of the diet do they comprise?

The main foods consumed by households are presented for four Pacific Island countries in Tables C1a and C1b. Except for Tonga, the analysis is based on the food consumption of households in the lowest three expenditure deciles, as calculated in national poverty reports.

The first table shows the main foods as a percentage of minimum daily energy consumption, estimated at 2100 calories per day for an average adult, for households in the lowest three income deciles. This table also shows the relationship between percentage of expenditure on main food items and the percentage of minimum daily energy consumption.

The second table shows the main foods as a percentage of the recommended daily intake of protein, estimated at 55 grams per day for an average adult, for households in the lowest three income deciles. This table also shows the relationship between percentage of expenditure on main food items and the percentage of the recommended daily intake of protein.

For the atoll countries (Kiribati and Tuvalu), sugar and rice are the top two foods consumed by poorer households, representing about half of the requirements of minimum daily energy consumption in Kiribati and about a quarter of the daily energy requirements in Tuvalu. For both countries consumption of these foods is higher in the urban centres compared to rural areas. While fresh fish is a major item in household expenditure for atoll countries, its contribution to minimum daily energy consumption is relatively less than other sugar based foods. However fresh fish makes up a large share of the daily protein needs.

For the fertile islands of Tonga and Vanuatu, local crops make up a larger share of the top foods. For example, in the rural areas of Vanuatu, island cabbage, sweet potato, cassava, yams and taro make up the main foods consumed by poorer households. However in the urban centres, rice and bread make up a larger share of the daily energy requirement (a quarter) as well as the largest share (almost a third) of household expenditure. In Tonga, the top two foods for all households in both urban and rural areas were chicken pieces and mutton flaps, which accounted for more than a quarter of the daily energy needs and about a fifth of the total household expenditure on food.

Households in the atoll countries obtain most of their daily requirements for protein from fresh fish. In the urban areas, fresh fish accounted for almost half of the daily protein needs in Kiribati and for a quarter of the recommended daily needs in Tuvalu, However including canned fish, fish made up more than half of the protein needs of Tuvaluan urban households. In the rural areas of both Tuvalu and Kiribati, the consumption of fresh fish accounted for more than 80% of daily protein needs.

In the urban areas of Vanuatu, most of the protein was obtained from canned fish and bread which made up about half of the recommended daily intake. However in the rural areas, local vegetables made up almost half of the recommended daily intake of protein. Most of the daily protein needs of households in Tonga were obtained from imported chicken pieces, which accounted for more than ninety percent of the needs of urban households and more than eighty percent of rural households. Together with mutton flaps, imported meats accounted for more than the total daily needs for protein in both urban and rural areas.

Table C1a: Main foods consumed by households in four Pacific Island countries (energy consumption kcal/d)

Kiribati 2006 Urban Area (Tarawa)					Kiribati 2006 Rural Area (Outer Islands)				
		% exp	Kcal/day	% MDEC			% exp	Kcal/day	% MDEC
1	Sugar	14.3	726	34.6%	1	Sugar	14	634	30.2%
2	Rice	22.2	375	17.9%	2	Rice	24.1	363	17.3%
3	Cakes/Donuts	3.1	183	8.7%	3	Coconut	1.8	363	17.3%
4	Fish (lagoon)	18.2	119	5.7%	4	Fish (lagoon)	15.2	235	11.2%
5	Tuna/Bonito	12.5	105	5.0%	5	Flour	4	185	8.8%
6	Flour	1.8	93	4.4%	6	Cakes/Donuts	2	105	5.0%
7	Shellfish	1.3	29	1.4%	7	Toddy	6.2	46	2.2%
8	Bread	1.4	22	1.0%	8	Breadfruit	8.2	29	1.4%
9	Tinned fish	2.7	21	1.0%	9	Tinned fish	3	21	1.0%
10	Coconut	0.6	10	0.5%	10	Tuna/Bonito	0.7	18	0.9%
	% of total	78.1	1707	81.3%		% of total	79.2	1999	95.2%
Tuvalu 2010 Urban Area (Funafuti)					**Tuvalu 2010 Rural Area (Outer Islands)**				
		% exp	Kcal/day	% MDEC			% exp	Kcal/day	% MDEC
1	Sugar	8.7	329	15.7%	1	Sugar	5.6	212	10.1%
2	Rice	13.8	255	12.1%	2	Rice	11.4	211	10.0%
3	Cabin biscuits	6.4	149	7.1%	3	Tuna/Bonito	13.3	197	9.4%
4	Flour	2.1	130	6.2%	4	Toddy (sweet)	9.0	190	9.0%
5	Tuna/Bonito	12.5	105	5.0%	5	Coconut (dry)	4.1	133	6.3%
6	Chicken (frozen)	13.9	82	3.9%	6	Reef fish	8.3	123	5.9%
7	Reef Fish	1.5	11	0.5%	7	Flour	1.9	121	5.8%
8	Toddy	0.5	10	0.5%	8	Cabin biscuits	4.8	113	5.4%
9	Canned fish	3.1	50	2.4%	9	Canned fish	1.4	22	1.1%
10	Corned beef can	2.5	10	0.5%	10	Corned beef can	0.9	4	0.2%
	% of total	65.0	1131	53.9%		% of total	60.7	1326	63.1%
Vanuatu 2006 Urban (Port Vila & Luganville)					**Vanuatu 2006 Rural Areas**				
		% exp	Kcal/day	% MDEC			% exp	Kcal/day	% MDEC
1	Bread	10.7	315	15.0%	1	Island Cabbage	4.8	415	19.8%
2	Rice	21	265	12.6%	2	Kumala	4	414	19.7%
3	Coconut dry	1.2	143	6.8%	3	Manioc	8.7	373	17.8%
4	Sugar	2.1	88	4.2%	4	Banana	11.3	212	10.1%
5	Manioc	2	84	4.0%	5	Coconut dry	3.9	168	8.0%
6	Kumala	3.3	73	3.5%	6	Yam	8.8	164	7.8%
7	Other tin fish	2.7	48	2.3%	7	Water Taro	1.8	159	7.6%
8	Tinned Tuna	4.1	47	2.2%	8	Rice	9.5	145	6.9%
9	Banana cooking	1.8	43	2.0%	9	Taro	12.5	42	2.0%
10	Yam	0.8	11	0.5%	10	Bread	1.5	4	0.2%
	% of total	49.7	1116	53.2%		% of total	66.8	2094	99.7%
Tonga 2009 Urban (Nuku'alofa)					**Tonga 2009 Rural Areas**				
		% exp	Kcal/day	% MDEC			% exp	Kcal/day	% MDEC
1	Chicken (Pieces)	9.4	407	19.4%	1	Chicken (Pieces)	9.6	369	17.6%
2	Manioc	3.1	338	16.1%	2	Manioc	3.7	363	17.3%
3	Yams	4.9	211	10.0%	3	Yams	5.6	210	10.0%
4	Mutton Flaps	8.5	199	9.5%	4	Mutton Flaps	8.5	177	8.4%
5	Mackerel	2.4	59	2.8%	5	Mackerel	2.7	59	2.8%
6	Taro Futuna	3.1	44	2.1%	6	Taro Futuna	3.9	49	2.3%
7	Fresh fish N.E.S	3.9	41	2.0%	7	Fresh fish N.E.S	3.8	37	1.7%
8	Flour (Plain)	2.1	26	1.2%	8	Flour (Plain)	2.6	29	1.4%
9	Corned beef	2.1	10	0.5%	9	Corned beef	2.7	10	0.5%
	% of total	39.5	1336	63.6%		% of total	43.1	1304	62.1%

Table C1b: Main foods consumed by households in four Pacific Island countries (protein consumption g/day)

Kiribati 2006 Urban Area (Tarawa)					Kiribati 2006 Rural Area (Outer Islands)				
		% exp	g/day	% RDI			% exp	g/day	% RDI
1	Cakes/Donuts	3.1	27	49.9%	1	Fish (lagoon)	15.2	43	78.7%
2	Fish (lagoon)	18.2	22	39.9%	2	Cakes/Donuts	2	16	28.5%
3	Rice	22.2	7	12.8%	3	Coconut	1.8	13	23.3%
4	Tinned fish	2.7	3	5.8%	4	Rice	24.1	7	12.4%
5	Flour	1.8	3	5.2%	5	Flour	4	6	10.3%
6	Tuna/Bonito	12.5	2	3.6%	6	Tinned fish	3	**3**	5.7%
7	Coconut	0.6	1	2.2%	7	Tuna/Bonito	0.7	2	3.9%
8	Shellfish	1.3	1	1.3%	8	Breadfruit	8.2	1	2.7%
9	Bread	1.4	0	0.3%	9	Toddy	6.2	0	0.5%
10	Sugar	14.3	0	0.0%	10	Sugar	14	0	0.0%
	% of total	72.7	66	120.8%		% of total	61.8	91	166.1%
Tuvalu 2010 Urban Area (Funafuti)					**Tuvalu 2010 Rural Area (Outer Islands)**				
		% exp	g/day	% RDI			% exp	g/day	% RDI
1	Canned fish	3.1	16	28.4%	1	Tuna/Bonito	13.3	23	41.8%
2	Tuna/Bonito	12.5	13	22.9%	2	Reef fish	8.3	23	41.3%
3	Corned beef (can)	2.5	10	18.6%	3	Canned fish	1.4	7	13.2%
4	Chicken frozen)	13.9	10	18.3%	4	Rice	11.4	6	10.1%
5	Rice	13.8	5	8.7%	5	Flour	1.9	4	6.8%
6	Flour	2.1	4	7.2%	6	Corned beef (can)	0.9	4	6.8%
7	Cabin biscuits	6.4	4	7.1%	7	Cabin biscuits	4.8	3	5.4%
8	Reef Fish	1.5	2	3.8%	8	Coconut (dry)	4.1	2	3.6%
9	Toddy	0.5	0	0.1%	9	Toddy (sweet)	9	1	1.4%
10	Sugar	8.7	0	0.0%	10	Sugar	5.6	0	0.0%
	% of total	65.0	63	115.0%		% of total	60.7	72	130.3%
Vanuatu 2006 Urban (Port Vila & Luganville)					**Vanuatu 2006 Rural Areas**				
		% exp	g/day	% RDI			% exp	g/day	% RDI
1	Bread	10.7	11	19.4%	1	Island Cabbage	4.8	6	10.9%
2	Tinned Tuna	4.1	10	18.4%	2	Manioc	8.7	6	10.5%
3	Rice	21	5	9.0%	3	Coconut dry	3.9	4	7.4%
4	Other tin fish	2.7	5	8.9%	4	Banana	11.3	3	5.1%
5	Coconut dry	1.2	2	2.7%	5	Taro	12.5	2	4.3%
6	Manioc	2	1	1.6%	6	Yam	8.8	2	4.2%
7	Kamala	3.3	1	1.4%	7	Kamala	4	2	3.0%
8	Banana cooking	1.8	1	0.9%	8	Rice	9.5	1	2.4%
9	Yam	0.8	0	0.1%	9	Water Taro	1.8	0	0.3%
10	Sugar	2.1	0	0.0%	10	Bread	1.5	0	0.1%
	% of total	49.7	34	62.5%		% of total	66.8	27	48.8%
Tonga 2009 Urban (Nuku'alofa)					**Tonga 2009 Rural Areas**				
		% exp	g/day	% RDI			% exp	g/day	% RDI
1	Chicken (Pieces)	9.4	50	91.1%	1	Chicken (Pieces)	9.6	45	82.6%
2	Mutton Flaps	8.5	17	31.7%	2	Mutton Flaps	8.5	16	28.2%
3	Flour (Plain)	2.1	8	14.4%	3	Flour (Plain)	2.6	9	15.9%
4	Fresh fish N.E.S	3.9	8	13.9%	4	Fresh fish N.E.S	3.8	7	12.3%
5	Manioc	3.1	5	9.5%	5	Manioc	3.7	6	10.3%
6	Mackerel	2.4	4	6.9%	6	Mackerel	2.7	4	6.8%
7	Taro Futuna	3.1	2	4.5%	7	Taro Futuna	3.9	3	5.0%
8	Yams	4.9	1	2.2%	8	Corned beef	2.7	1	2.5%
9	Corned beef	2.1	1	2.2%	9	Yams	5.6	1	2.1%
	% of total	39.5	97	176.5%		% of total	43.1	91	165.7%

C2. How has consumption changed over time?

The distribution of food groups consumed by households in Tonga and Tuvalu is shown in Figure C2 and Table C2 as a percentage of total expenditure – cash and non-cash - on food. The analysis compares the trends in food consumption over two survey periods.

In Tonga, almost a third of food expenditure is spent on meat and poultry, an increase of two percentage points since the first survey eight years previous. Around a quarter of expenditure is spent on vegetables, up four percentage points. Bread and cereals, and fish and seafood, also contribute to a large proportion of food expenditure of households.

On the main island of Tuvalu, there has been a substantial decline in the proportion of expenditure on fish and seafood, decreasing by six percentage points over six years. The largest proportion of food expenditure is now on spent on bread and cereals, especially rice, which accounts for more than a quarter of all food expenditure. There also has been a large decline in the proportion of expenditure on fruits and vegetables. However, the trend is reversed in the outer islands, where a larger proportion of food expenditure is spent on fish, and fruits and vegetables.

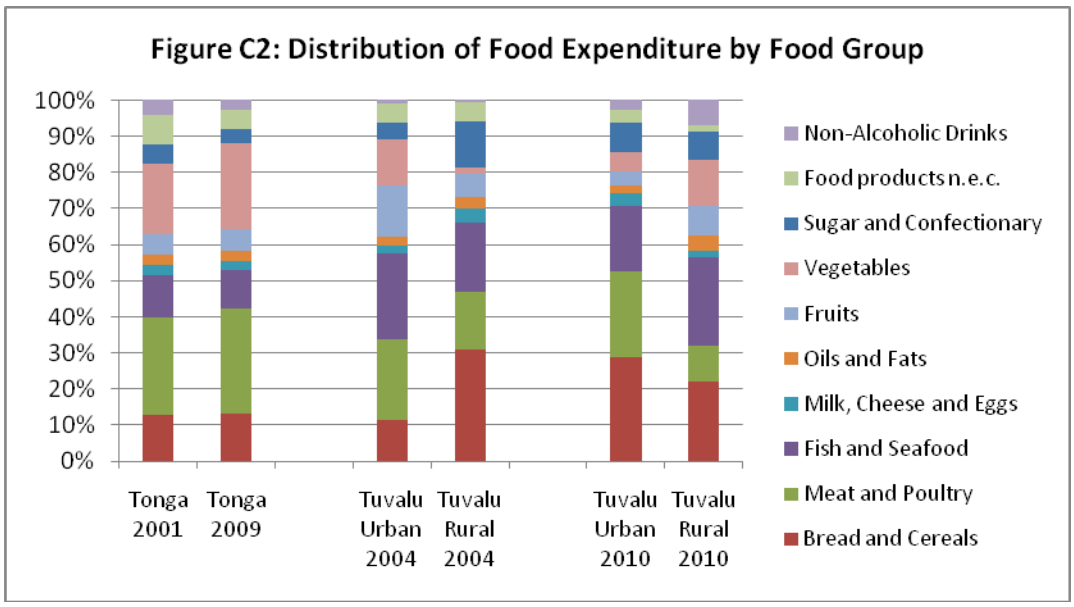


Table C2: Percentage of Food Expenditure by Food Group

Food Group	Tonga	Tonga	Tuvalu (Urban)		Tuvalu (Rural)	
	2001	2009	2004	2010	2004	2010
Bread and Cereals	12.7%	13.1%	11.6%	28.6%	31.0%	22.2%
Meat and Poultry	27.0%	29.3%	22.1%	23.9%	15.8%	9.7%
Fish and Seafood	11.8%	10.6%	24.0%	18.1%	19.2%	24.7%
Milk, Cheese and Eggs	2.9%	2.5%	2.2%	3.5%	3.8%	1.8%
Oils and Fats	2.8%	2.8%	2.2%	2.4%	3.3%	4.1%
Fruits	5.8%	5.9%	14.3%	3.9%	6.6%	8.2%
Vegetables	19.4%	23.9%	12.8%	5.1%	1.7%	12.8%
Sugar & Confectionary	5.2%	4.0%	4.6%	8.3%	12.6%	7.6%
Food products n.e.c.	8.3%	5.3%	5.3%	3.4%	5.5%	1.9%
Non-Alcoholic Drinks	4.1%	2.6%	1.0%	2.8%	0.5%	7.0%
Totals	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

C3. Which foods have become more or less important?

Tables C3a and C3b compare the differences between expenditure on main food items as a proportion of cash food expenditure for two different survey periods.

For Tonga, the largest change in expenditure occurred for chicken pieces where there was a four percentage point increase in proportional cash expenditure. There was a slight decline in proportional expenditure on mutton flaps and corned beef. There was very little change in the percentage of expenditure on local crops, such as yams and taro.

In Tuvalu, a larger proportion of cash food expenditure was spent on rice and frozen chicken than six years ago, a difference of four and three percentage points respectively. There was very little difference in the proportion of cash expenditure on other imported food items, such as sugar and biscuits, except flour which declined by three percentage points. Expenditure on fresh and canned fish increased slightly as a proportion of cash expenditure on food, but only represents less than ten percent of all food expenditures.

Table C3a: Comparison of Common Food Items as a Percentage of Cash Food Expenditure (Tonga 2001 & 2009)

	Top 10 foods 2001	% Point Change	% of food expenditure	Top 10 foods 2009	% of food expenditure
1	Mutton Flaps	-0.9	9.4%	Chicken(Pieces)	9.5%
2	Chicken (Pieces)	4.1	5.5%	Mutton Flaps	8.5%
3	Bread (White)		5.0%	Yams	5.4%
4	Corned beef	-2.0	4.6%	Restaurant	4.1%
5	Yams	1.0	4.4%	Fresh fish N.E.S	3.9%
6	Frozen Fish N.E.S		3.6%	Taro Futuna	3.7%
7	Fresh Fish N.E.S	0.4	3.4%	Manioca	3.6%
8	Restaurant meals	1.0	3.1%	Mackerel	2.7%
9	Taro Dryland	0.7	3.0%	Corned beef	2.6%
10	Sugar (Raw)		2.4%	Flour (Plain)	2.5%
	Total Top Ten Food Expenditure		**44.4%**		**46.3%**

Table C3b: Comparison of Common Food Items as a Percentage of Cash Food Expenditure (Tuvalu 2004 & 2010)

	Top 10 foods 2004	%Point Change	% of food expenditure	Top 10 foods 2010	% of food expenditure
1	Rice	3.7	13.7%	Rice	17.4%
2	Chicken (frozen)	2.6	12.3%	Chicken (frozen)	14.9%
3	Sugar	-0.5	10.1%	Sugar	9.6%
4	Cabin biscuits	0.8	6.2%	Cabin biscuits	7.0%
5	Tuna/Bonito	0.7	5.7%	Tuna/Bonito	6.4%
6	Flour	-3.1	5.6%	Bread	3.5%
7	Corned Beef	-1.1	3.8%	Butter	3.4%
8	Bread	-0.2	3.7%	Corned Beef	2.7%
9	Milk	-0.1	2.4%	Tin fish	2.6%
10	Tin fish	1.1	1.5%	Flour	2.5%
	Total Top Ten Food Expenditure		**65.0%**		**70.0%**

C4. How has consumption of own production changed over time as a proportion of total expenditure on food?

The trend in the proportion of food expenditure from non-cash sources (household produce and gifts) for Tonga and Tuvalu is shown in Figure C4 and Table C4.

Whereas Tonga has experienced a proportional increase in non-cash expenditure over an eight year period, Tuvalu has in fact seen a decline in the proportion of food expenditure on home produce over a six year period.

Overall in Tonga, there has been a ten percentage point increase in households consuming food from own produce or from gifts, though the increase is significantly larger in rural areas.

In Tuvalu, non-cash expenditures on food decreased by more than ten percent as a proportion of total food expenditure. However the decrease was less in the outer islands, around five percentage points, than in the urban area of Funafuti.

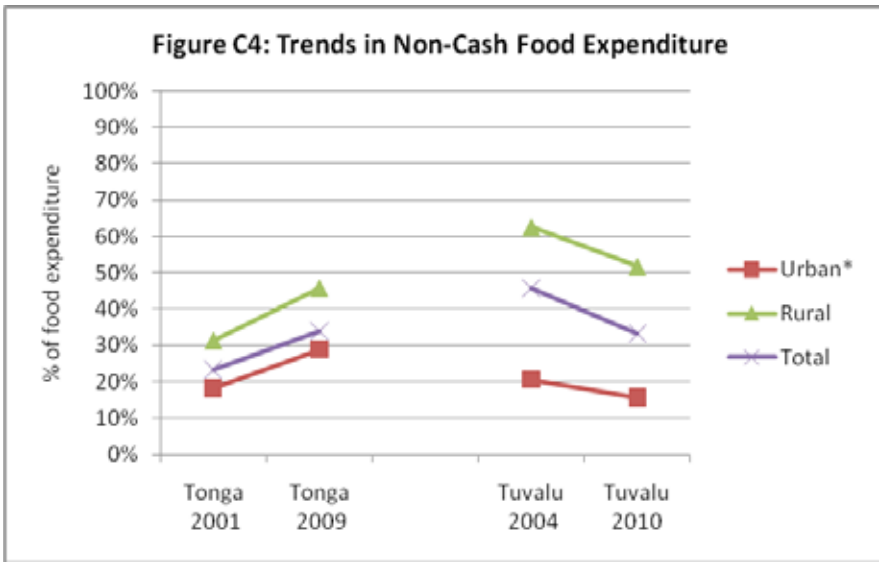


Table C4: Percentage of Food Expenditure from Non-Cash Expenditure (Home Produce & Gifts)

Country	Year	Urban*	Rural	Total
Tonga	2001	18.2%	31.2%	23.3%
Tonga	2009	28.9%	45.8%	33.9%
Tuvalu	2004	20.6%	62.6%	45.7%
Tuvalu	2010	15.7%	51.7%	33.2%

*Note: * Urban area of Tonga refers to all of Tongatapu*

A1. What are the food groups that are home produced?

The distribution of main food groups for home produced foods as a percentage of own consumption expenditure is shown in Figure A1 and Table A1 for the four Pacific Island countries.

The consumption of home produced vegetables comprised the highest proportion of own consumption expenditure in Tonga and Vanuatu, representing almost sixty percent of this type of expenditure. Whereas fish and seafood were common items of own produce expenditure in Tonga, there was a greater amount of expenditure on fruits in Vanuatu.

For Tuvalu and Kiribati, fish and seafood comprised a larger proportion of home produced expenditure than other food groups, representing between forty and fifty percent of own consumption expenditure. Locally produced fruits and, to a lesser extent, vegetables were also common items of expenditure, especially in the urban areas.

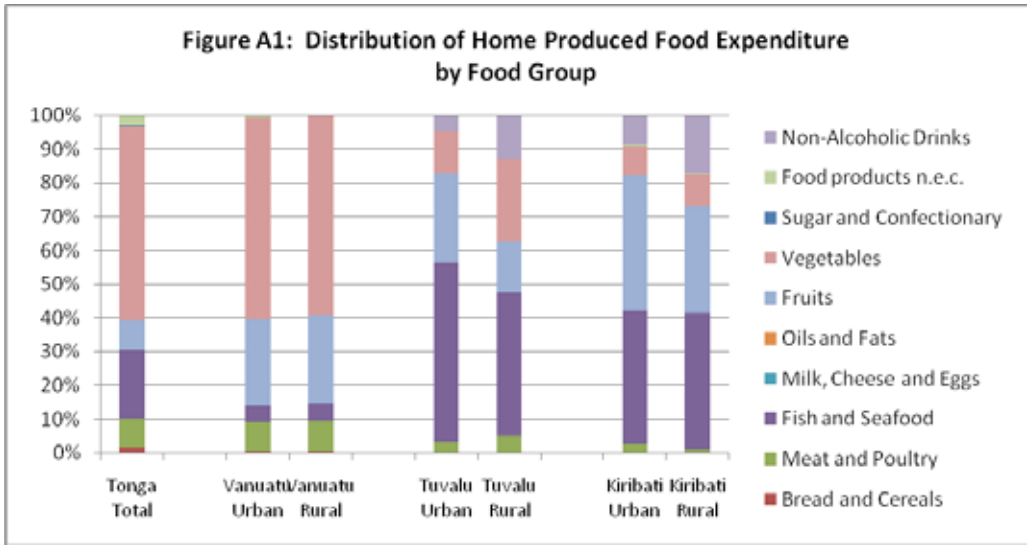


Table A1: Home Produced Food Expenditure by Food Group (latest year)

Food Groups	Tonga Total	Vanuatu Urban	Vanuatu Rural	Tuvalu Urban	Tuvalu Rural	Kiribati Urban	Kiribati Rural
Bread and Cereals	1.5%	0.5%	0.3%	0.0%	0.0%	0.0%	0.0%
Meat and Poultry	8.7%	8.8%	9.2%	3.1%	5.1%	2.5%	0.9%
Fish and Seafood	20.2%	4.6%	4.9%	53.1%	42.4%	39.7%	40.7%
Milk, Cheese, Eggs	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Oils and Fats	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fruits	8.8%	25.7%	26.3%	26.6%	15.2%	40.1%	31.4%
Vegetables	57.6%	59.7%	59.2%	12.5%	24.2%	8.4%	9.6%
Sugar, Confectionary	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Food products n.e.c.	3.0%	0.5%	0.1%	0.0%	0.0%	0.6%	0.2%
Non-Alcoholic Drinks	0.0%	0.1%	0.0%	4.7%	13.1%	8.6%	17.2%
Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

A2. How much food is purchased?

Figure A2 and Table A2 show the distribution of cash food expenditure by food group for the four Pacific Island countries.

Apart from Tonga, the food group on which households spend most of their cash is bread and cereal (mainly rice). Expenditure on this food group is higher in the rural areas, where almost half of all cash food expenditure is spent on rice and flour. Kiribati and Tuvalu households spend a larger proportion of cash purchases on sugar and confectionary than the other countries.

In Tonga, meat and poultry comprises a high proportion of purchased food, representing more than a third of all cash food expenditure. Households from the other Pacific countries also spend a relatively large proportion of their cash on meat and poultry, though the amount is proportionately larger in urban areas.

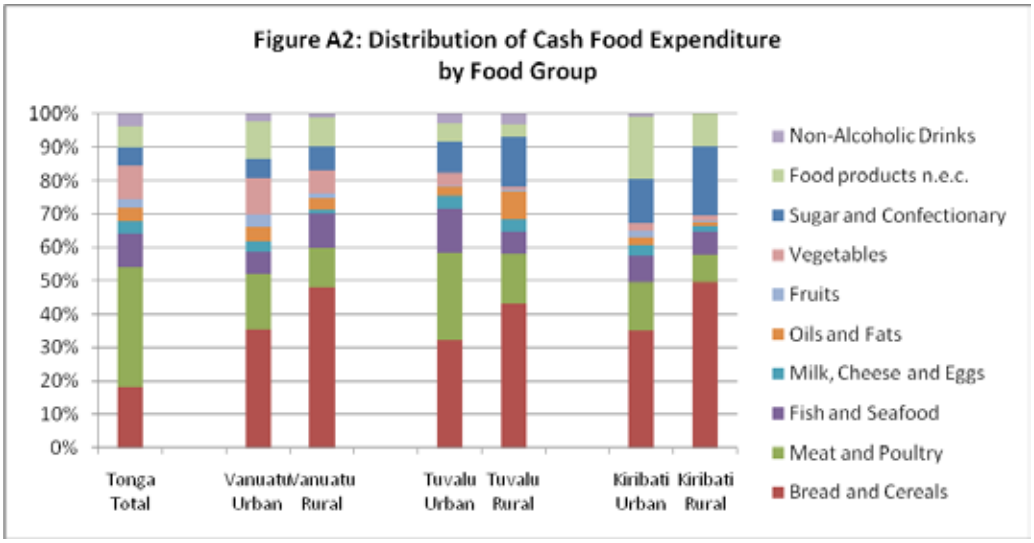


Table A2: Cash Food Expenditure by Food Group (latest year)

Food Group	Tonga Total	Vanuatu Urban	Vanuatu Rural	Tuvalu Urban	Tuvalu Rural	Kiribati Urban	Kiribati Rural
Bread and Cereals	18.3%	35.4%	47.9%	32.4%	43.1%	35.1%	49.7%
Meat and Poultry	35.7%	16.7%	11.6%	25.9%	14.9%	14.4%	8.0%
Fish and Seafood	10.2%	6.7%	10.6%	13.3%	6.8%	7.9%	7.1%
Milk, Cheese and Eggs	3.6%	3.3%	1.3%	3.9%	3.6%	3.1%	1.5%
Oils and Fats	4.2%	4.1%	3.2%	2.8%	8.3%	2.4%	1.3%
Fruits	2.5%	3.7%	1.5%	0.3%	0.5%	2.1%	0.6%
Vegetables	10.2%	11.1%	6.9%	3.8%	1.2%	2.2%	1.1%
Sugar and Confectionary	5.3%	5.6%	7.1%	9.5%	14.7%	13.1%	20.8%
Food products n.e.c.	6.4%	11.4%	8.4%	5.3%	3.7%	18.5%	9.8%
Non-Alcoholic Drinks	3.7%	2.1%	1.4%	2.8%	3.2%	1.1%	0.1%
Totals	**100.0%**	**100.2%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

E1. What percentage of household expenditure is used to purchase food?

The percentage of total household expenditure (cash and non-cash) used to purchase food is shown for the four Pacific Island countries and separately for urban and rural areas in Figure E1 and Table E1. Around a half of all household expenditure is spent on purchasing food in Kiribati, Vanuatu and Tuvalu. In Tonga more than a third of household expenditure is used to purchase food.In all countries, a greater proportion of total expenditure of rural households was spent on food purchases. This difference is especially noticeable in Vanuatu and Tuvalu where there was around a 25 percentage point difference between urban and rural areas. In Kiribati, the difference was around 10 percentage points, and in Tonga, only four percentage points separated spending by rural and urban households.Around a third of household expenditure was spent on food purchases in the urban areas of Tonga and Vanuatu. However in the main islands of Kiribati and Tuvalu, more than two-fifths of household expenditure was spend on food.

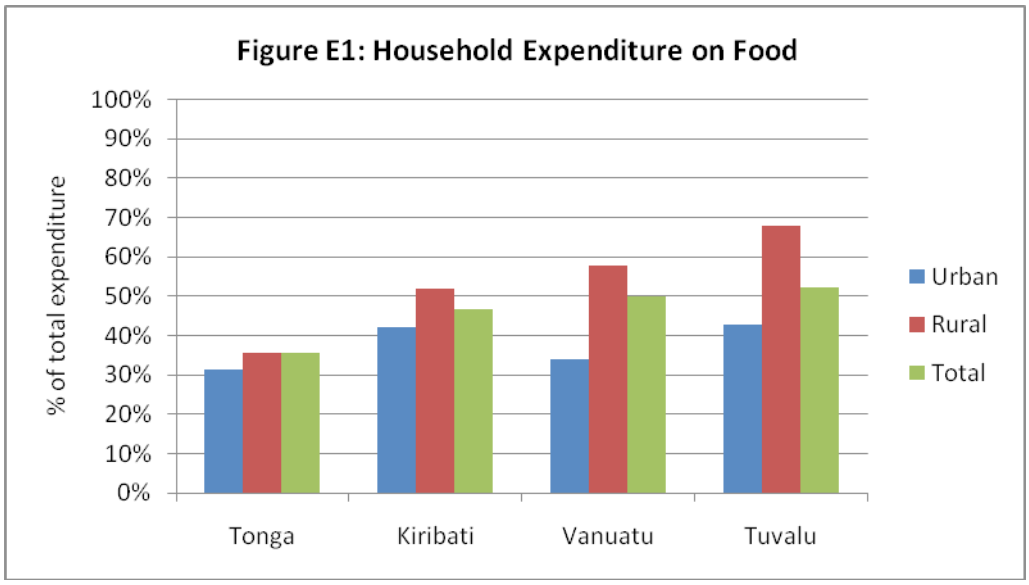


Table E1: Food as Percentage of Total Household Expenditure

Country	Year	Urban	Rural	Total
Tonga	2009	31.5%	35.6%	35.7%
Kiribati	2006	42.1%	52.0%	46.8%
Vanuatu	2006	34.1%	57.9%	49.8%
Tuvalu	2010	42.9%	67.7%	52.1%

E2. How has the percentage of household expenditure used to purchase food changed over time?

The trends in the percentage of total household expenditure used to purchase food (cash and non-cash expenditure) in Tonga and Tuvalu is shown separately for urban and rural areas in Figure E2 and Table E2. Between the two surveys in each country, there have been changes in the proportion of total expenditure on food purchases. In Tonga food expenditure has declined relatively by four percentage points over an eight year period, where as in Tuvalu there has been a three percentage point increase in relative food expenditure. In Tuvalu, the change in relative food expenditure is greater in the urban area where there has been a seven percentage point increase. In Tonga there has been little change in the proportion of food expenditure in both rural and urban areas.

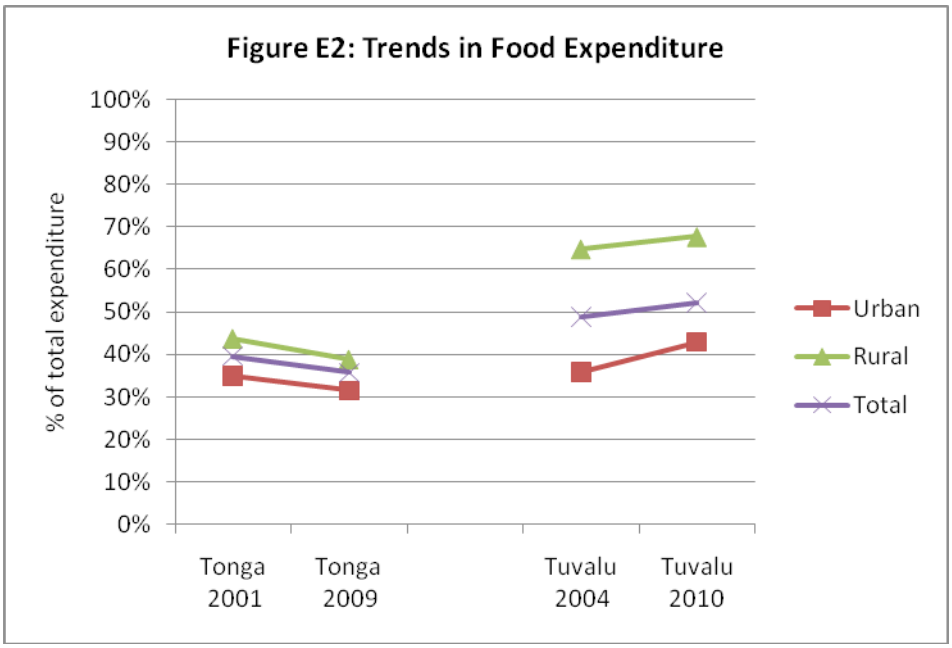


Table E2: Percentage of Total Expenditure on Food

Country	Year	Urban	Rural	Total
Tonga	2001	35.0%	43.7%	39.6%
Tonga	2009	31.5%	38.8%	35.7%
Tuvalu	2004	35.9%	64.8%	48.9%
Tuvalu	2010	42.9%	67.7%	52.1%

E3. What percentage of food expenditure is in cash, in kind and home produced?

The main types of food expenditure are food purchased by cash, in-kind (bartering & gifts), and home produced for own consumption. The distributions of these types of food expenditure are shown in the Figure E3 and Table E3 for the four Pacific Island countries. Apart from Vanuatu, around two-thirds of food expenditures are cash purchases. In Vanuatu, cash purchases comprise only two-fifths of food expenditures with more than half of food expenditure coming from home produced foods. In Kiribati, more than a third of food expenditure was from home produced foods and less than a third in Tuvalu. Only a fifth of food expenditure in Tonga was home produced.For all countries only a small percentage of food expenditure was from in-kind exchanges or gifts. In-kind expenditures contributed only 3% - 8% of household food expenditure.

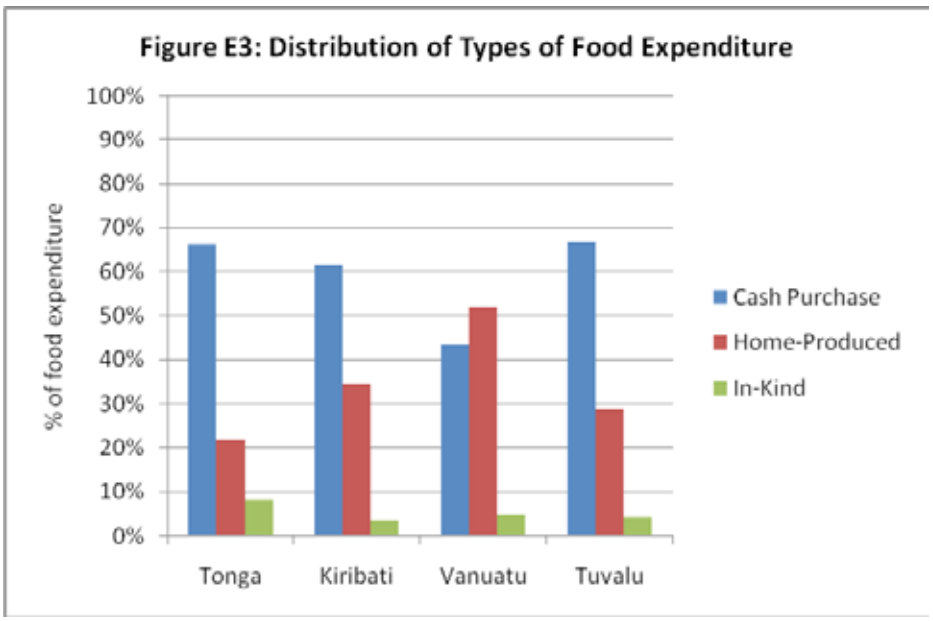


Table E3: Percentage of Food Expenditure in Cash, In-Kind and Home Produced

Country	Year	Cash Purchase	Home-Produced	In-Kind	
Tonga	2009	66.1%	21.9%	8.1%	*
Kiribati	2006	61.5%	34.6%	3.4%	*
Vanuatu	2006	43.3%	51.9%	4.8%	
Tuvalu	2010	66.8%	28.8%	4.3%	

*Note: * excludes non-consumption expenditure*

E4. How has the percentage of cash food expenditure changed over time?

The percentage of cash food expenditure as a proportion of all food expenditure by households in Tuvalu and Tonga is shown for different time periods in Figure E4 and Table E4.In Tonga the percentage of cash food expenditure has declined for both urban and rural households. Whereas three quarters of all households made cash purchases during the first survey in 2001, only two-thirds of households made cash purchases in 2009. Both urban and rural households in Tuvalu spent proportionately more on cash purchases between the two survey periods. That is, the overall percentage of cash food expenditure increased from around half of all food expenditure in 2004 to two-thirds in 2010.

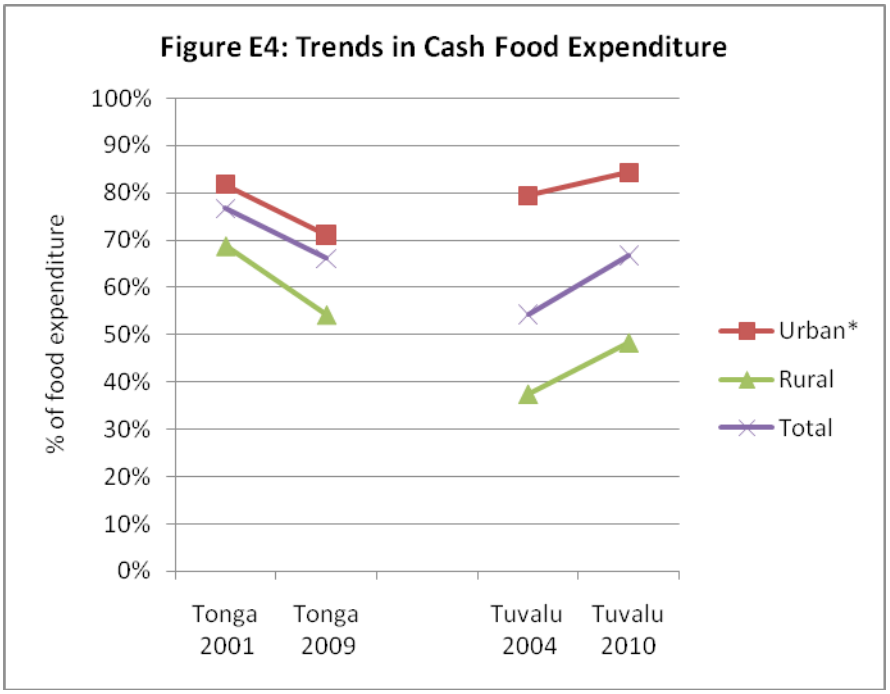


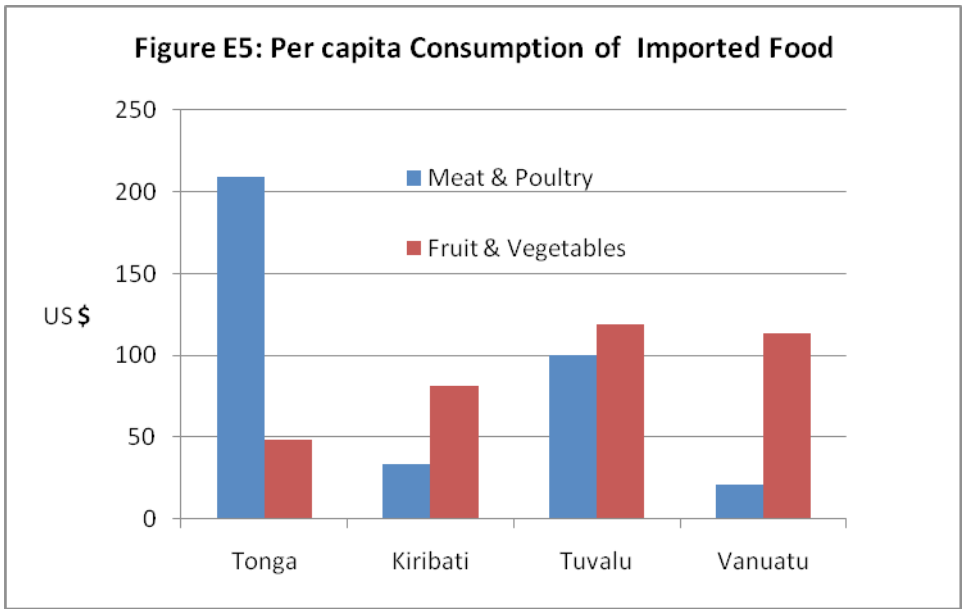
Table E4: Trends in Proportion of Food Expenditure from Cash Purchases

Country	Year	Urban*	Rural	Total
Tonga	2001	81.8%	68.8%	76.7%
Tonga	2009	71.1%	54.2%	66.1%
Tuvalu	2004	79.4%	37.4%	54.3%
Tuvalu	2010	84.3%	48.3%	66.8%

Note: Urban area for Tonga is all Tongatapu island

E5. What percentage of food expenditure is spent on imported foods?

The per-capita consumption of imported food and the proportion of food expenditure spent on imported food items for the four Pacific Island is shown in Figure E5 and Table E5. The percentages of imported food are reported only for food groups that are also locally produced: that is, meat and poultry, fruit and vegetables, fish and seafood.On a per-capita basis, Tonga consumes twice as much imported meat and poultry as Tuvalu, six times as much as Kiribati, and ten times as much as Vanuatu – though it should be noted that Vanuatu has a local meat industry. Both Tuvalu and Vanuatu import more fruits and vegetables than Kiribati or Tonga.Overall, households in Tonga and Tuvalu spent a larger share of food expenditure on imported items than Kiribati or Vanuatu. In Tonga and Tuvalu almost two-thirds of total food expenditure was spent on imported food, mainly meat and poultry. More than half of food expenditure in Kiribati was spent on imported food. However in Vanuatu, households spent only two-fifths of food expenditure on imported items, most commonly on canned fish.



Source: Pacific Trade Statistics

Table E5: Percentage of Food Expenditure from Imported Items (estimated)

Country	Year	Fish & Seafood	Fruit & Veges	Meat & Poultry	Total Food
Tonga	2009	31.8%	11.8%	95.4%	63.8%
Kiribati	2006	14.8%	10.9%	54.9%	55.2%
Vanuatu	2006	53.3%	6.8%	36.2%	41.5%
Tuvalu	2010	8.5%	12.3%	90.0%	62.3%

E6. What is the proportion of food expenditure that is composed of gifts?

The percentage of total food expenditure from food gifts given away and received from other households is shown for each of the four Pacific Island countries in Figure E6 and Table E6.Overall gifts of food accounted for less than one tenth of total food expenditure. However a higher proportion of food expenditure came from food gifts in Tonga (15%) compared to the other countries. Vanuatu had the lowest expenditure on gifts accounting for only five percent of total expenditure.In Tonga and Tuvalu, proportionately more gifts were received than given away, whereas in Kiribati and Vanuatu slightly more gifts were given away.

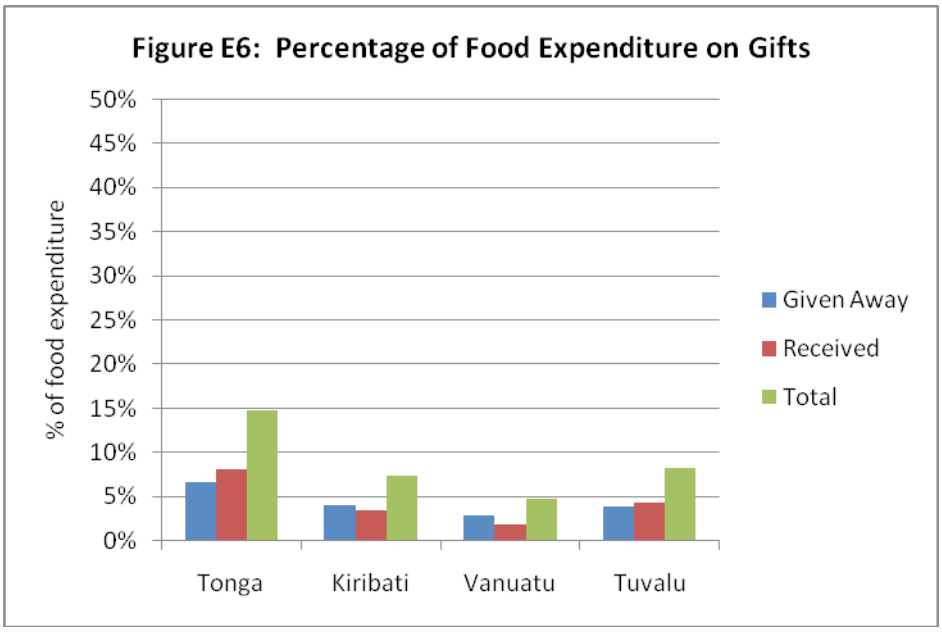


Table E6: Percentage of Food Expenditure Composed of Gifts

Country	Year	Given Away	Received	Total
Tonga	2009	6.6%	8.1%	14.7%
Kiribati	2006	4.0%	3.4%	7.4%
Vanuatu	2006	2.9%	1.9%	4.8%
Tuvalu	2010	3.9%	4.3%	8.2%

I1. What proportion of household income comes from home produce?

The proportion of household income from the consumption of home produce is shown in Figure I1 and Table I1 for the four Pacific Island countries for urban and rural areas separately.Vanuatu households receive the largest proportion of income from home produce compared to the other countries, where more than a quarter of household income comes from home produce. However, almost two-fifths of rural household income comes from the consumption of home produce.In the rural areas of Tonga, the income received from consumption of own produce was less than in the other countries. Less than one fifth of rural household income came from home produce, compared to less than one tenth of urban household income.For the atoll countries, more than a quarter of household income in rural areas is derived from home produce, In the urban areas relatively less income comes from home produce consumption, though urban households in Kiribati received more income from consumption of home produce than households in Tuvalu.

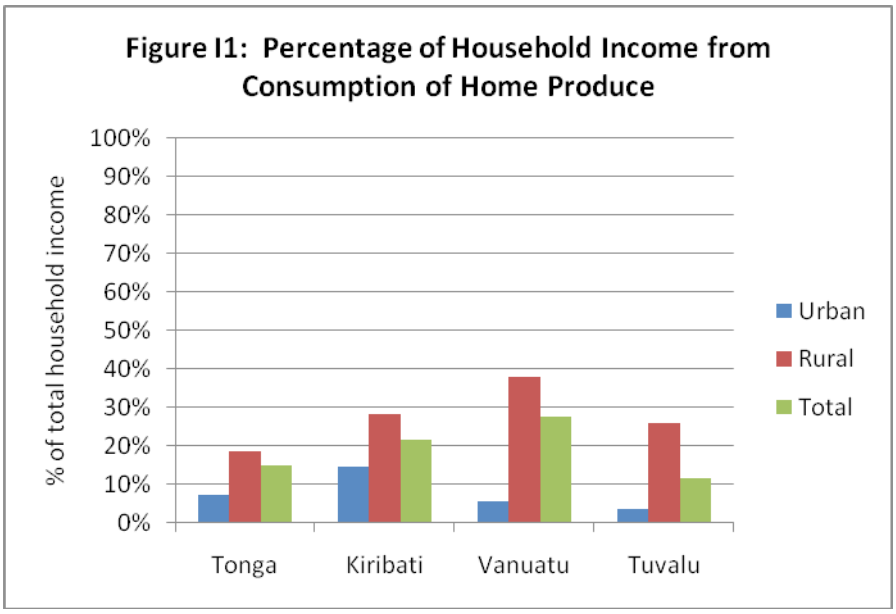


Table I1: Percentage of Household Income from Home Produce (Own Consumption)

Country	Year	Urban	Rural	Total
Tonga	2009	7.3%	18.7%	14.8%
Kiribati	2006	14.6%	28.2%	21.5%
Vanuatu	2006	5.7%	37.9%	27.7%
Tuvalu	2010	3.6%	26.0%	11.6%

I2. What percentage of household income from home produce is generated by agriculture, livestock, and fisheries?

The distribution of household income that is derived from the sales of home produce from agriculture, livestock, and fisheries is shown for the four Pacific Island countries in Figure I2 and Table I2.For Tonga and Vanuatu, most of the home produce income comes from the sale of agricultural produce, where as for Kiribati and Tuvalu a larger proportion of sales come from fisheries. More than half of the home produce sales in Kiribati and a third in Tuvalu are from the sale of fish and seafood.Livestock sales comprises more than a third of home produce income in Tonga and Tuvalu.

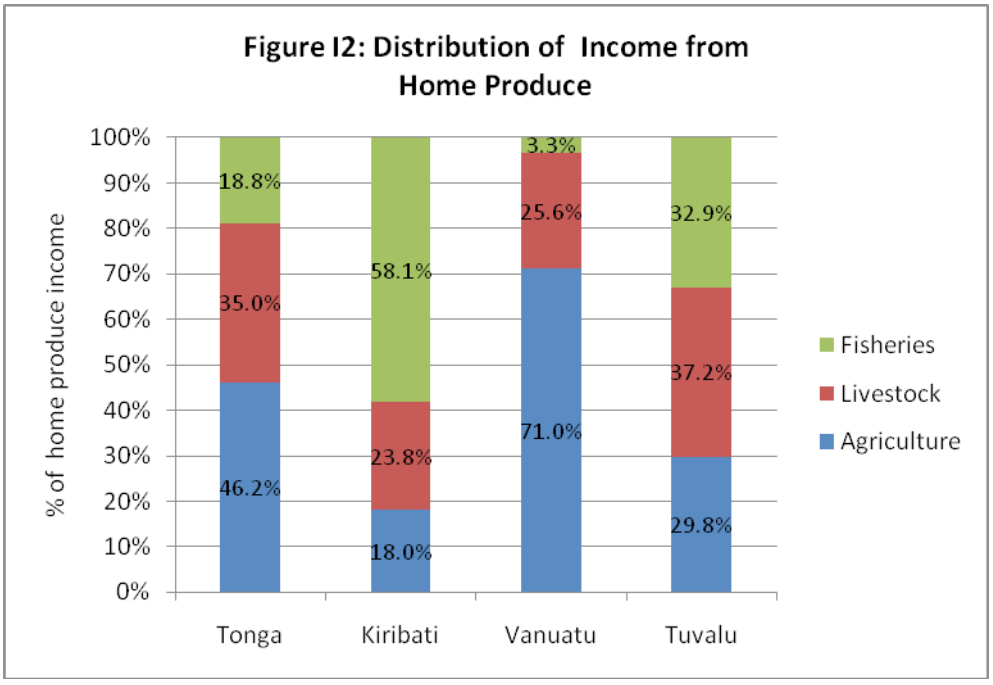
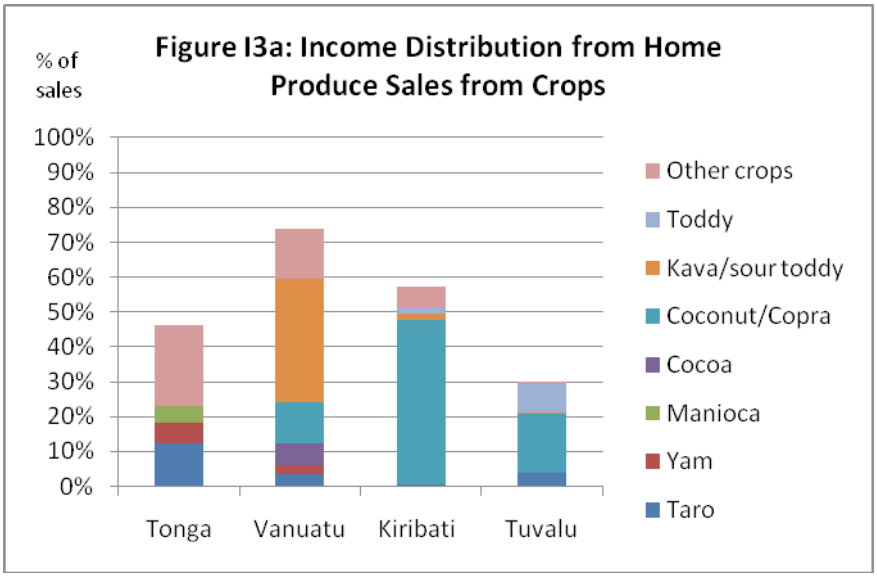


Table I2: Percentage Distribution of Home Produce Sales from Agriculture, Livestock and Fisheries

Country	Year	Agriculture	Livestock	Fisheries	Total
Tonga	2009	46.2%	35.0%	18.8%	100.0%
Kiribati	2006	18.0%	23.8%	58.1%	100.0%
Vanuatu	2006	71.0%	25.6%	3.3%	100.0%
Tuvalu	2010	29.8%	37.2%	32.9%	100.0%

I3. Which particular crops/species are the most important in terms of income generation?

The percentage distribution of income from the home produce sales of agricultural food crops, livestock species and fish is shown for each of the four Pacific Island countries in Figures I3a, I3b and Table I3. In the agricultural countries, the most important food crops in terms of income generation are: taro, yam, cassava, cocoa and coconut. In the atoll countries, coconut is the main crop, accounting for most of the income from agricultural produce.Apart from Vanuatu, most of the income from the sale of livestock comes from pigs. Sales of cattle make up a substantial proportion of income from home produced sources in Vanuatu and Tonga. Little income was derived from the sale of chickens, which were more likely to be consumed by own households.For the atoll countries a third of the income from sales of home produce came from fish, though the differences in sales between lagoon and ocean fish species is not known.



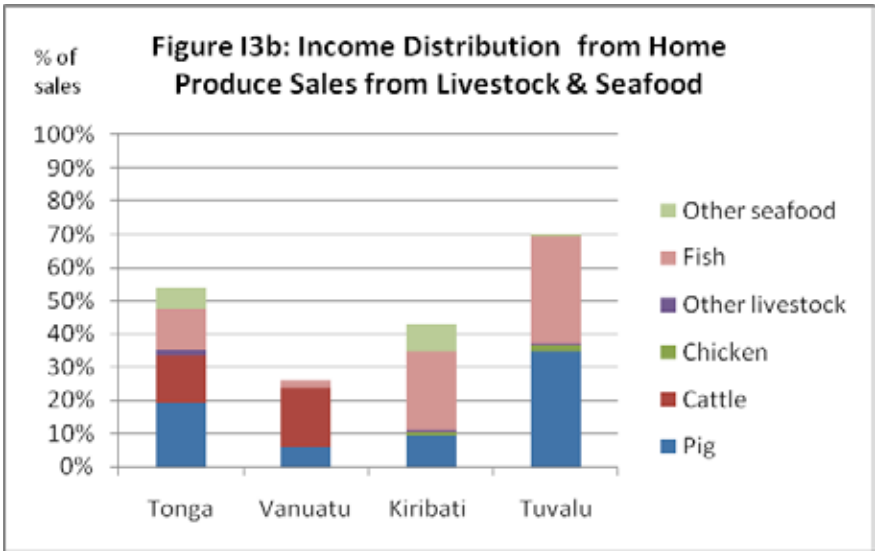


Table I3: Percentage Distribution of Household Income from Home Produce Sales from Crops, Livestock and Seafood

	Tonga	Vanuatu	Kiribati	Tuvalu
Crops				
Taro	12.4%	3.4%	0.7%	3.8%
Yam	5.7%	2.7%	0.0%	0.0%
Manioc	5.1%	0.0%	0.0%	0.0%
Cocoa	0.0%	6.4%	0.0%	0.0%
Coconut/Copra	0.0%	11.5%	46.9%	16.9%
Kava/sour toddy	0.0%	35.5%	2.0%	0.5%
Toddy	0.0%	0.0%	1.8%	8.0%
Other crops	23.0%	14.4%	5.7%	0.7%
Total Crops	**46.2%**	**73.9%**	**57.1%**	**29.9%**
Livestock				
Pig	19.5%	6.2%	9.4%	34.6%
Cattle	14.0%	17.6%	0.0%	0.0%
Chicken	0.0%	0.0%	0.8%	2.2%
Other livestock	1.6%	0.0%	1.0%	0.4%
Total Livestock	**35.1%**	**23.8%**	**11.2%**	**37.2%**
Seafood				
Fish	12.4%	2.3%	23.5%	32.4%
Other seafood	6.4%	0.0%	8.2%	0.5%
Total Seafood	**18.8%**	**2.3%**	**31.7%**	**32.9%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

I4. What proportion of household income is composed of food gifts?

The percentage of household income from food gifts for each of the four Pacific Island countries for urban and rural areas separately is shown in Figure I4 and Table I4.Overall, food gifts received from other households accounted for between two and five percent of total household income. In Tonga and Vanuatu food gifts made a larger contribution to household income, compared to gifts received by households in Tuvalu and Kiribati.There were very small differences in the amount of income received from food gifts from households in rural and urban areas. However, slightly more income was received from gifts in rural households in Tonga and less income from rural households in Vanuatu.

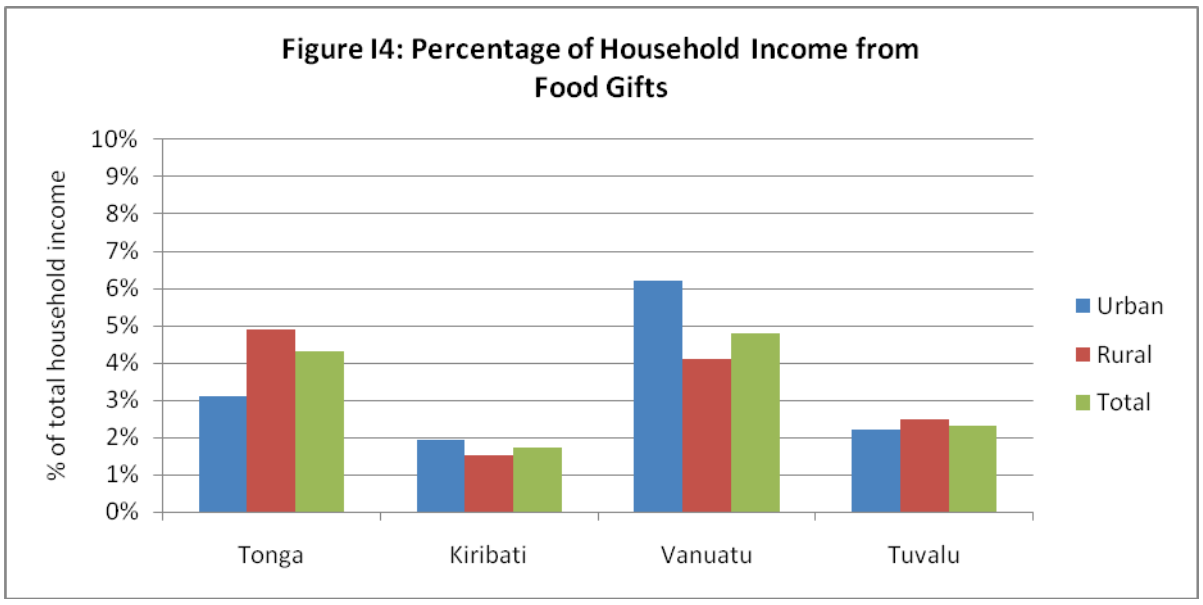


Table I4: Percentage of Household Income from Food Gifts

Country	Year	Urban	Rural	Total
Tonga	2009	3.1%	4.9%	4.3%
Kiribati	2006	1.9%	1.5%	1.7%
Vanuatu	2006	6.2%	4.1%	4.8%
Tuvalu	2010	2.2%	2.5%	2.3%

Technical Notes

Apart from Tonga, the analysis of minimum daily energy consumption (MDEC) and the recommended daily intake (RDI) of protein was based on the lowest three expenditure deciles.

As per poverty profiles, MDEC is defined as 2100 calories per day for an adult equivalent. As per the Pacific Island Food Composition tables, the RDI is defined as 55 grams of protein per day for an adult male.

The kilocalorie (Kcal) (energy) value from the South Pacific Food Composition Tables was applied to each of the top ten food expenditure items to give a total Kcal value for recorded consumption. The daily per capita adult equivalent Kcal consumption values represented by each item were then calculated.

The protein value from the South Pacific Food Composition Tables was applied to each of the top ten food expenditure items to give a total protein value for recorded consumption. The RDI per capita adult equivalent protein consumption values represented by each item were then calculated.

The urban area for Tonga is defined as the area surrounding Nuku'alofa on Tongatapu island.
The urban area for Tuvalu is defined as all of Funafuti Island (the capital).
The urban area for Kiribati is defined as the area of South Tarawa.
The urban area of Vanuatu is the area surrounding Port Vila and Luganville

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Appendix Table 1: Food crops and livestock production, area harvested, yields and trends, Pacific region

FOOD CROPS							
Production (tons)	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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)	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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)	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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

Growth Rates (%)							
Production	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
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

LIVESTOCK							
Production (tons)	**1960s**	**1970s**	**1980s**	**1990-94**	**1995-99**	**2000-04**	**2005-08**
Beef and Buffalo Mea	6572.89	11102.8	15201.9	17223.6	17344.6	16994.6	16767.5
Eggs Primary	2821.22	3784.8	5823.3	7670	9632.4	10748	10869.25
Milk,Total	35755.89	55253.3	50849.6	67490.4	65176	61942.6	64230
Poultry Meat	2341.33	3958.3	8545.7	12483.2	15982.6	18339	22068.25
Sheep and Goat Meat	510.22	408.9	691.2	775.4	1020.6	1117	1086.75
Growth Rates (%)							
Beef and Buffalo Mea	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

Source: Table 7 in Sombilla, M.A. 2010. Sustainable Food Security in the Pacific Islands - An Analysis of Threats and Prospects in the Face of Climate Change. Manila: ADB. Draft. Data source: FAOStat, Accessed 15 April 2010 (faostat.fao.org).

Appendix Table 2: Agriculture and infrastructure storm damage, Pacific island countries, recent years

27 May 2011	(Radio Australia) ---- Flooding in Choiseul Province in **Solomon Islands** has reportedly caused extensive damage to food crops in at least 10 villages.
2009 (January)	**Fiji** - the "dry" Western side of the Island received over 45 cm of rain in a day (normally <25cm/month), most of the low lying areas in the country was underwater for days and in places experienced flood levels of up to 3–5 meters. Agriculture and infrastructure were the hardest hit with loss of more than F$100 million
2007	In **Tonga**, the squash crop which had been producing 50% of the country's exports by value was more than halved.
2005 (February to March)	**Cook Islands**, over a period of five weeks, saw five tropical cyclones, four of which were category 5 (Meena 02/02/05, Nancy 10/02/05, Olaf 14/0205, Percy 25/02/05 and Rae 04/03/05) devastated the islands causing widespread damage to infrastructure and property. The cost of the damage was initially assessed at (cost of recovery) US$5, 531,200.
2004 (January)	In **Niue**, Cyclone Heta caused devastation to people, properties, government and industry, infrastructure, agriculture and the economy with an estimated damage cost of more than US$60 million (or NZ$89.1 million). The taro supply for the island was destroyed and primary forest areas shredded.
2004	In **Vanuatu**, the most comprehensive assessment was conducted for Cyclone Ivy which estimated a total cost at US$12 million. Cyclone Ivy affected 50,000 people and one fatality, 90% of water resources, 70% of roads, 60% of health infrastructure, 112 schools and over 80% of food crops were damaged. Heavy flooding of the Wainibuka and Rewa rivers in Fiji in April 2004 damaged between 50% and 70% of crops. (Barnett 2007)
2003	**Fiji** experienced severe flooding and losses from Cyclone Ami in key development sectors: housing, education, health, agriculture, tourism, sugar, business, infrastructure, telecommunications and power supply with an estimated cost of damage at FJ$104.4 million and over 70% of this damage was to the public sector. The cyclone also caused fourteen deaths and over US$35 million in lost crops in Fiji. (Barnett 2007)
1999	In **Tuvalu**, even a short dry period of 2-3 weeks without rain can lead to water shortages. In 1999, a severe drought (i.e. period without rain longer than 2-3 weeks) forced the government to purchase a desalination plant from Japan (very expensive infrastructure) which now costs AU$30,000 per month to run using diesel fuel. This is deemed to be unsustainable and the long-term costs could be prohibitive.
1998 and 2007	**Federated States of Micronesia** – in several islands in the states declared major drought emergencies due to food and water shortages during El Niño conditions; groundwater supplies dwindled to an alarming level. Many schools and public facilities were without adequate water supplies. Rivers dried up and wells were dangerously low with increasing salinity (*Source*: Micronesia: Drought - OCHA-01: 27-Mar-98, ref="http://cidi.org/disaster/98a/0051.html")
1997-1998	Almost all of the islands in the Pacific sustained crop damage and loss of both food and cash crops during the drought following the 1997/98 ENSO. In **Papua New Guinea**, the Australian government spent more than AUD$30 million delivering food aid to isolated areas of the highlands and low-lying islands affected by drought, with further losses in coffee production. The drought and frost emergency damaged not only subsistence farming but also the production of cash crops such as coffee and cocoa. Most significantly for the national economy, some mines have had to close as the level of water has dropped in the rivers on which they depend for supplies and the transport of ore.On **Pohnpei,** over half the banana trees died or were seriously stressed; on **Yap** taro losses were estimated at 50–65%. The **Marshall Islands** required supplies of relief food from in January 1998, due to Typhoon Paka (other islands requested relief food in May, during the drought).In **Fiji**, the 1997/98 El Niño Southern Oscillation (ENSO) event caused losses in the sugar cane industry of around FJ$104 million while other agriculture losses including livestock death amounted to FJ$15 million. It affected 40% of the country's sugar cane crops and directly impacted the livelihoods of an estimated 28,000 households (FAO 2010)
1990	**Niue** turned from a food exporting country into one dependent on imports for the next two years as a result of cyclone Ofa (FAO 2010).

Sources: Main source: SPC Land Resources Division. *Vulnerability of Pacific Island Countries*. (http://www.spc.int/lrd/index.php?option=com_content&view=article&id=535&Itemid=306).Other sources as noted:Barnett, J. 2007. Food Security and Climate Change in the South Pacific. *Pacific Ecologist*, Winter 2007, p.32–36.FAO. 2010. *Pacific Food Security Toolkit Building Resilience to Climate Change Root Crop and Fishery Production*. Rome. (http://www.fao.org/docrep/013/am014e/am014e.pdf).Patz, J.A., and C.L. Parker. 2000. Climate and Health in Small Island States. Workshop Background Paper *in Climate Variability and Change and their Health Effects in Pacific Island Countries*, Apia, Samoa, 25-28 July 2000: Workshop Report. WHO/SDE/OEH/01.1

Appendix Table 3: Potential of coastal fisheries to meet demand in Pacific island countries through the 21st century

Countries in which coastal fish production will meet consumption demand[a]	Countries in which coastal fish production can meet consumption demand but faces infrastructure and distribution problems	Countries in which coastal fish production will not meet consumption demand
Cook Islands	Federated States of Micronesia	Fiji Islands
Marshall Islands	Kiribati[b]	Nauru
Palau	Niue	Papua New Guinea
	Tonga	Solomon Islands
	Tuvalu	Samoa
		Timor-Leste[c]
		Vanuatu

Note: Demand means supply of 35 kg of fish per person per year and is based on the A2 climate change emissions scenario of the Intergovernmental Panel on Climate Change.

[a] Potential fish production is derived from two estimates: estimated production from catch data and coral reef production of 3 tonnes per square kilometre per year.

[b] Kiribati can only meet demand until 2050 under the A2 scenario.Source, except Timor-Leste: Bell, J.D., J.E. Johnson, and A.J. Hobday, eds. *Vulnerability of Fisheries and Aquaculture in the Tropical Pacific to Climate Change*. Noumea: Secretariat of the Pacific Community. In press.

[c] Fisheries are expected to provide 10 kg/person/year; this does not account for future population growth or climate change scenarios. Source: Guterres, A. 2003. Planning for Fisheries Development in East Timor. In Agriculture: New Directions for a New Nation — East Timor (Timor-Leste), edited by H. da Costa, C. Piggin, C. J. da Cruz, and J. J. Fox. *ACIAR Proceedings No. 113*. Canberra: ACIAR.

Appendix Table 4: 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 (B1)[b]		Worse Scenario (A2)	
	2035	2100	2035	2100
Total Pacific	19	12	19	-7
Western fishery	11	0	11	-21
Eastern fishery	37	43	37	27

[a] Western fishery = 15oN to 20oS and 130oE to 170oE; eastern fishery = 15oN to 15oS and 170oE to 150oW.

[b] The scenarios represent those used by the Fourth Intergovernmental Panel on Climate Change (IPCC) 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., J. Hampton, R. Brill, S. Nicol, I. Senina, B. Calmettes, H. Pörtner, L. Bopp, T. Ilyina, and J. Sibert. (in press) Vulnerability of Oceanic Fisheries in the Tropical Pacific to Climate Change. In: J.D. Bell, J.E. Johnson, and A.J. Hobday, eds. *Vulnerability of Fisheries and Aquaculture in the Tropical Pacific to Climate Change*. Noumea: Secretariat of the Pacific Community.

Appendix Table 5: Average prices of fish per kilogram paid by urban households

Country	Survey Year	Currency	Fresh tuna	Canned mackerel
Cook Is	2004	NZD	9.00	9.00
Fiji	2003	FJD	5.81	2.42
FSM	2005	USD	2.80	5.90
Kiribati	2006	AUD	2.00	5.00
Nauru	2006	AUD	2.00	5.00
Palau	2006	YSD	2.20	3.85
Solomon	2005	SBD	10.00	26.00
Tuvalu	2004	AUD	2.35	5.00
Vanuatu	2007	VAT	230.00	360.00

Source: Household income and expenditure surveys.

Appendix Table 6: National responses to the impact of climate change on food security in Pacific Island Countries

COUNTRY	PROJECT/ PROGRAMME	COUNTRY PARTNER	ACTIVITY
Cook Islands	Adaptation Fund	National Environment Service; Office of the Prime Minister, Central Policy and Planning Division	Enhancing resilience of communities of CI through integrated CCA and DRM measures: Climate-resilient agricultural practices implemented in at least 5 islands
Kiribati[1]	NAPA Rank 6 NAPA Rank 7	Ministry of Environment, Lands and Agricultural Development (MELAD)Ministry of Fisheries and Marine Resources Development (MFMRD), Ministry of Health and Medical Services (MHMS)	Agricultural Food Crops DevelopmentCoral Reef Restoration, Monitoring and Stock Enhancement
Samoa	NAPA[2] Rank 5 NAPA Rank 8 NAPA	Ministry of AgricultureMinistry of Natural Resources, Environment and Meteorology (MNREM) and Ministry of Agriculture (MOA) in close collaboration with communitiesMinistry of Agriculture, National Institute of Water and Atmospheric Research (NIWA)	Maintain economically subsistence agriculture and sustain food security in communitiesEstablish and/or strengthen community-based conservation programmes for the protection of highly vulnerable terrestrial and marine biodiversityIntegrating Climate Change Risks in the Agriculture and Health Sectors in Samoa (ICCRA&HSS) Establishment of climate change and agriculture early warning system; agricultural management plans and strategies are revised to incorporate climate risk forecasting and adaptive planning National soil and crop maps updated and enhanced with functionalities for climate risk and productivity modelling under different climate conditionsAdaptive agricultural crop management piloted in vulnerable agricultural areas
Solomon Islands	NAPA[3] Rank 1 NAPA Rank 5 Adaptation Fund	Ministry of Environment, Climate Change, Meteorology and Disaster Management (MECMD) and the Ministry of Agriculture and Livestock (MAL)	Managing the impacts of and enhancing the resilience to climate change and sea-level rise on agriculture and food security, water supply and sanitation, human settlements, human health and educationImprove understanding of the effects of climate change and climate variability on the inshore and tuna fishery resourcesEnhancing resilience of communities in Solomon Islands to the adverse effects of climate change in agriculture and food security Promote and pilot community-adaptation activities enhancing food security and livelihood resilience in pilot communities in at least 3 selected regions;
Tuvalu	NAPA[4] Rank 2 NAPA Rank 5	Department of Lands and Survey (DOLS), Public Works Department (PWD)and KaupuleDepartment of Fisheries (DOF), Department of Energy (DOE) and Kaupule	Increasing subsistence pit grown pulaka productivity through the introduction of a salt-tolerant pulaka speciesStrengthening of Community based Conservation Programmes on Highly vulnerable near-shore marine ecosystems
Vanuatu[5]	NAPA	Dept of Agriculture & Rural Development (DARD)	To enhance food security and hence resilience of the economy to the adverse effects of climate change

Appendix Table 7: Development partner responses to the impact of climate change on food security in Pacific island countries

COUNTRY	PROJECT/ PROGRAMME	COUNTRY PARTNER	ACTIVITY	IMPLEMENTATION TIME-FRAME	DEVELOPMENT PARTNER
National projects					
Cook Islands	SPC	Ministry of Agriculture	Evaluation of traditional and imported crops for tolerance to waterlogging	2011 to 2012	AusAID ICCAI
	SPC	Ministry of Agriculture	Agrobiodiversity studies to determine the impact of climate change on local agrobiodiversity	2011 to 2012	AusAID ICCAI
Federated States of Micronesia (FSM)	SPC	Office of Environment and Emergency Management and College of Micronesia	Assessment of the Impact of climate change on food security in FSM: including the identification of adaptation measures to enhance the resilience of food systems.	2011 to 2012	DCCEE ICCAI
Fiji	PACC, SPREP	Land and Water Resources Division, MPI	Develop capacity for the design and implementation of drainage and drainage networks		GEF (UNDP)
	PACE-SD,	Relevant ministries and key stakeholders	Rural Community Climate Change Adaptation Project (water stress, coastal erosion, food security and human health)	2010 to 2012	AusAID AusAID ICCAI
	USP	Agriculture Division, MPI	Generation of phenotypic data for the development of APSIM model for cassava to enable impacts of climate change to be predicted	2010 to 2012	AusAID ICCAI & GEF Small Grant
	SPC	Agriculture Division, MPI	Agrobiodiversity studies to determine the impact of climate change on local agrobiodiversity (Viwa Atoll and Vanuavatu Development Committee)	2011 to 2012	GEF Small Grant
	SPC	The Totoya Development Committee, WWF.	Food security as a community catalyst for climate change adaptation and enhancing watershed management and restoration on Totoya Island	2009 to 2011	USP
	USP		Sugar cane yields and salinization	2010 to 2012	GIZ-CCCPIR
	USP	Dept of Environment, MPI	Development of national adaptation strategy for the land based natural resources sectors	2011	UNDP
	SPC				
	Not known	Ministry of Primary Industries	Strategy for disaster risk management and reduction for the agriculture sector	Not known	
Kiribati	SPC	MELAD	Salinity tolerance screening of giant swamp taro cultivars	2011	AusAID ICCAI

Palau	PACC, SPREP	Ngatpang Maritime Authority	Develop capacity to design guidelines and technologies to enhance resilience of their coastal food systems to the impacts of climate change		GEF (UNDP)
	SPC/FAO	Bureau of Agriculture, Bureau of Marine Resources	Draft of food security policy with climate change incorporated	2012-13	GIZ - CCCPIR
	SPC	Palau Community College	Agrobiodiversity studies to determine the impact of climate change on local agrobiodiversity	2010 to 2011	AusAID ICCAI
	SPC		Evaluation of traditional and imported crops for tolerance to salinity and waterlogging	2011 to 2012	AusAID ICCAI
	SPC/SPREP	BOA and BMR	Training of extension officers and NGO staff for agriculture, forestry and fisheries on climate change and adaptation actions	2012 (planned)	GIZ - CCCPIR
	SPC	BMR	Training on coastal marine resource assessment and inshore fish aggregating device deployment	2012 (planned)	GIZ - CCCPIR
	SPC	BOA	Rehabilitation of degraded land on Babeldaob	2013-14 (planned)	GIZ - CCCPIR
Papua New Guinea	PACC, SPREP	Department of Agriculture and Livestock	Develop capacity to design and demonstrate innovative programmes for managing drought, for example, use of low input/low technology irrigation systems		GEF (UNDP)
	SPC	NARI	Evaluation of PNG taro core collection for salinity and waterlogging tolerance	2009 to 2011	Global Crop Diversity Trust
	SPC	NARI, FPDA, UNITECH, SPC (IACT)	Development of low-cost food processing technology for farmers	2012 -2014 (planned)	GIZ- CCCPIR
	SPC	NARI, FPDA, UNITECH, SPC (CePaCT)	Test new drought tolerant crop varieties at Kivori PACC site	2012 -2014(planned)	GIZ- CCCPIR
	FRI	PNGFA, PACC/DAL	Apply/transfer research results from the Forestry Research Institute on high salt-tolerant species to the Kivori site for coastal protection, flooding and inundation	2012 – 2014 (planned)	GIZ- CCCPIR
RMI	SPC	Ministry of Resources and Development	Introduction of salt tolerant crops	2012 to 2014 (planned)	GIZ - CCCPIR

Samoa	SPC	USP	Agrobiodiversity studies to determine the impact of climate change on local agrobiodiversity	2011 to 2012	AusAID ICCAI
		USP	Assessment of adaptive capacity	2011 to 2012	AusAID ICCAI
		USP	Breeding taro for drought tolerance	2010 to 2012	AusAID ICCAI
		USP	Establishing a root crop collection to support adaptation to climate change	2011 to 2012	AusAID ICCAI
	SPC		Conduct pilot project on detecting and identifying climate resilience trees / plants for wind breaks	2012-14 (planned)	GIZ – CCCPIR
	SPC		Conduct pilot project on detecting and identifying climate resilience trees / plants for wind breaks	2012-2014 (planned)	GIZ – CCCPIR
	SPC		Cost/benefit analysis of coastal fish attraction devices impacts on communities	2012 (planned)	GIZ - CCCPIR
Solomon Islands	PACC, SPREP	Department of Agriculture and key stakeholders	Build capacity to design and implement an integrated food security programme that will reduce vulnerability to the effects of climate change		
	PACE-SD	Ministries of Agriculture and Meteorology	Assessing the ecological impacts of climate change on root crop production in high islands: a case study in Santa Isabel	January to December 2011	U-GCCA
Tonga	SPC	MAFFF	Evaluation of local and imported crops for climate tolerant traits	2011 to 2012	AusAID ICCAI
		MAFFF	Establishing a root crop collection to support adaptation to climate change	2011 to 2012	AusAID ICCAI
		MAFFF	Planting materials network analysis	2011 to 2012	AusAID ICCA
	SPC	MECC/MAFFF	Demonstration sites for sustainable land and agro-forestry management on Eua including integrated land use planning, establishment of nurseries and forest rehabilitation.	2009-2015	IGIZ-CCCPIR
			Demonstration site for climate change adaptation technologies on Nakolo (Tongatapu) including integrated land use planning, trial of climate resilient crops.	2009-2015	GIZ-CCCPIR
			National climate change adaptation strategy for land based natural resources	2009-2015	GIZ-CCCPIR
	SPC/SPREP	MECC	Implementation of relevant food security activities included in the Joint National Action Plan for climate change adaptation and disaster risk reduction		AusAID(?)

Tuvalu	SPC/SPREP	Ministry of Natural Resources	Improve access of communities to coastal fisheries and aquaculture	2012-2014 (planned)	GIZ- CCCPIR
	SPC	MNR	Trial saltwater tolerant crops (e.g. Salt water pulaka) with communities and rehabilitate pulaka pits	2012-2014 (planned)	GIZ- CCCPIR
	SPC		Review and strengthen fish aggregating device programme	2012	GIZ- CCCPIR
Tuvalu	PACE-SD	Fisheries Department, Community leaders, Meteorology	Climate change and Fisheries in Tuvalu: An adaptation strategy for resilience and sustainability of the sector	January 2011 to December 2013	EU-GCCA
	SPC	Tuvalu Agriculture Department and Ministry of Natural Resources	Evaluation of banana diversity and adaptation to climate variability in Tuvalu	2011 to 2012	FAO
Vanuatu	SPC	MAQFF	Demonstration sites for sustainable land and forestry management to promote climate change adaptation and food security enhancement – including integrated land use planning, trials of climate resilient crops, establishment of community livestock breeding programme, crop and tree nurseries.	2010-2015	GIZ-CCCPIR
		MAQFF	National climate change adaptation strategy for land based natural resources (including collection and documentation of traditional practices for disaster risk reduction and management)	2010-2015	GIZ-CCCPIR
		MAQFF/Meterology	Developing seasonal forecasts that translate forecast information into practical information that farmers can use	2010-2015	GIZ-CCCPIR
		MAQFF	Incorporating climate change into agri-business training	2010-2015	GIZ-CCCPIR

Regional projects					
Fiji and other PICs	PACE-SD	MPI, FNU, USP, Ministry of Agriculture and Meteorology	Development of Pacific Islanders' capacity to use Decision Support System for Agro-technology (DSSAT) to simulate the impacts of climate variability and change on Pacific islands' important food and economic crops	May 2011 to June 2012	USAID
15 PICs including East Timor	PACE-SD	Relevant ministries and key stakeholders	Building capacities and resilience of communities food security and other stresses induced by climate variability and climate change	2011 to 2014	EU-GCCA
Fiji and other PICs	PACE-SD	Fisheries, Environment and Meteorological Departments	Ocean acidification potential in Western Pacific ocean and its implications for fisheries productivity Evaluation of climate ready crop collection for addressing climate variability and climate change	2011 to 2014	EU-GCCA
Atoll countries	SPC	Ministries of Agriculture and Natural Resources	Evaluating the impact of salinity on swamp taro cultivation in the atolls and the genotypic influence on salinity tolerance	2010 to 2012	AusAID ICCAI
22PICTs	SPC	Ministries of Agriculture and Natural Resources	Strengthening food security through access to climate tolerant crop diversity	2009-2012	AusAID ICCAI
All PICTs	SPC	Fisheries Divisions	Vulnerability of Pacific fisheries and aquaculture to climate change: to assess impact of climate change on Pacific fisheries. Results will be used to guide adaptation decision making and fisheries management across the region.	2008-2011 2010 – 2012	AusAID AusAID
Pohnpei, FSM; Majuro, Marshall Islands; Manus, PNG; Abemama, Kiribati and Funafuti, Tuvalu	SPC	Fisheries Divisions	Establishment of coastal fisheries monitoring activities to enable the tracking of climate change impacts of fish stocks and coastal habitats; includes conducting national base-line surveys and capacity building with fisheries department staff and communities at the pilot sites in selected countries.		
FSM, Palau, Samoa, PNG, Solomon Islands, Kiribati, Tuvalu and Nauru	SPC	Fisheries	Community-based adaptation programme in coastal areas (marine and terrestrial)	2012 to 2015	GIZ CCCPIR
All PICTs	UNDP	Ministries of Agriculture and Meteorology	Agro-meteorology training and capacity building in using meteorological information for assessing impacts on agriculture. Various models presented.	2011	UNDP (South-South partnership)
Fiji, Samoa, PNG	SPC	Ministries of Agriculture (dept of livestock and private sector)	Capacity building for assessing the vulnerability and developing adaptation strategies for the livestock sector in the Pacific		GIZ – CCCPIR
Fiji, Vanuatu, Solomon Islands and PNG	IFPRI		Impacts of climate change on food security: Vulnerability and risk assessment, adaptation and mitigation strategies complementing national climate change plans, policy options and recommendations	2011	ADB

ADB = Asian Development Bank, AusAID = Australian Agency for International Development, BMA = Bureau of Marine Resources, BOA = Bureau of Agriculture, CBO = community-based organization, CCCPIR = Coping with Climate Change in the Pacific Region, CEPACT = Centre for Pacific Crops and Trees, DAL = Department of Agriculture and Livestock, DCCEE = Department of Climate Change and Energy Efficiency, DOE = Department of Energy, DOF = Department of Fisheries, DOLS = Department of Lands and Survey, EU = European Union, FAO = Food and Agriculture Organization of the United Nations, FNU = Fiji National University, FPDA = Fresh Produce Development Agency, FSM = Federated States of Micronesia, GCCA = Global Climate Change Alliance, GEF = Global Environment Facility, GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit, IACT = Increasing Agricultural Commodity Trade project, ICCAI = International Climate Change Adaptation Initiative, IFPRI = International Food Policy Research Institute, MAFFF = Ministry of Agriculture, Food, Forestry and Fisheries, MAQFF = Ministry of Agriculture, Quarantine, Forestry and Fisheries, MECC = Ministry of Environment and Climate Change, MELAD = Ministry of Environment, Lands and Agricultural Development, MFMRD = Ministry of Fisheries and Marine Resources Development, MHMS = Ministry of Health and Medical Services, MNR = Ministry of Natural Resources, MNREM = Ministry of Natural Resources, Environment and Meteorology, MOA = Ministry of Agriculture, MOH = Ministry of Health, MPI = Ministry of Primary Industries, MPWU = Ministry of Public Works and Utilities, NAPA = National Adaptation Programme of Action, NARI = National Agriculture Research Institute, NGO = nongovernmental organisation, PACC = Pacific Adaptation to Climate Change project, PACE-SD = Pacific Centre for Environment and Sustainable Development, PICTs = Pacific Island Countries and Territories, PNGFA = Papua New Guinea Forestry Authority, PWD = Public Works Department, RMI = Republic of the Marshall Islands, RnD = (Ministry of) Resources and Development, SPC = Secretariat of the Pacific Community, SPREP = South Pacific Regional Environment Programme, UNDP = United Nations Development Programme, UNFCCC = United Nations Framework Convention on Climate Change, UNITECH = University of Technology, USAID = United States Agency for International Development, USP = University of the South Pacific, WWF = World Wildlife Fund.

(Footnotes)

1 Kiribati data from http://unfccc.int/resource/docs/napa/kir01.pdf

2 Samoa data from http://unfccc.int/resource/docs/napa/sam01.pdf

3 NAPA data from http://www.adaptationlearning.net/solomon-islands-napa

4 NAPA data from http://unfccc.int/resource/docs/napa/tuv01.pdf

5 Vanuatu data from http://unfccc.int/files/adaptation/napas/application/pdf/37_van_pp.pdf