PACIFIC FOOD SECURITY TOOLKIT

BUILDING RESILIENCE TO CLIMATE CHANGE

ROOT CROP AND FISHERY PRODUCTION

USP
THE UNIVERSITY OF THE SOUTH PACIFIC

SPREP

FAO
FIAT PANIS

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ROOT CROP AND FISHERY PRODUCTION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, ROME 2010

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This booklet draws heavily from a variety of online resources, books and reports. The majority of these resources are included as reference tools in Section 6. Any failure to acknowledge reference sources is unintentional. The fisheries module draws strongly on the recent work led by the Strategic Engagement Policy and Planning Facility at the Secretariat of the Pacific Community and several co-authors. Conservation International's preparation of Module 3 on the role of ecosystems in food security is also much appreciated.

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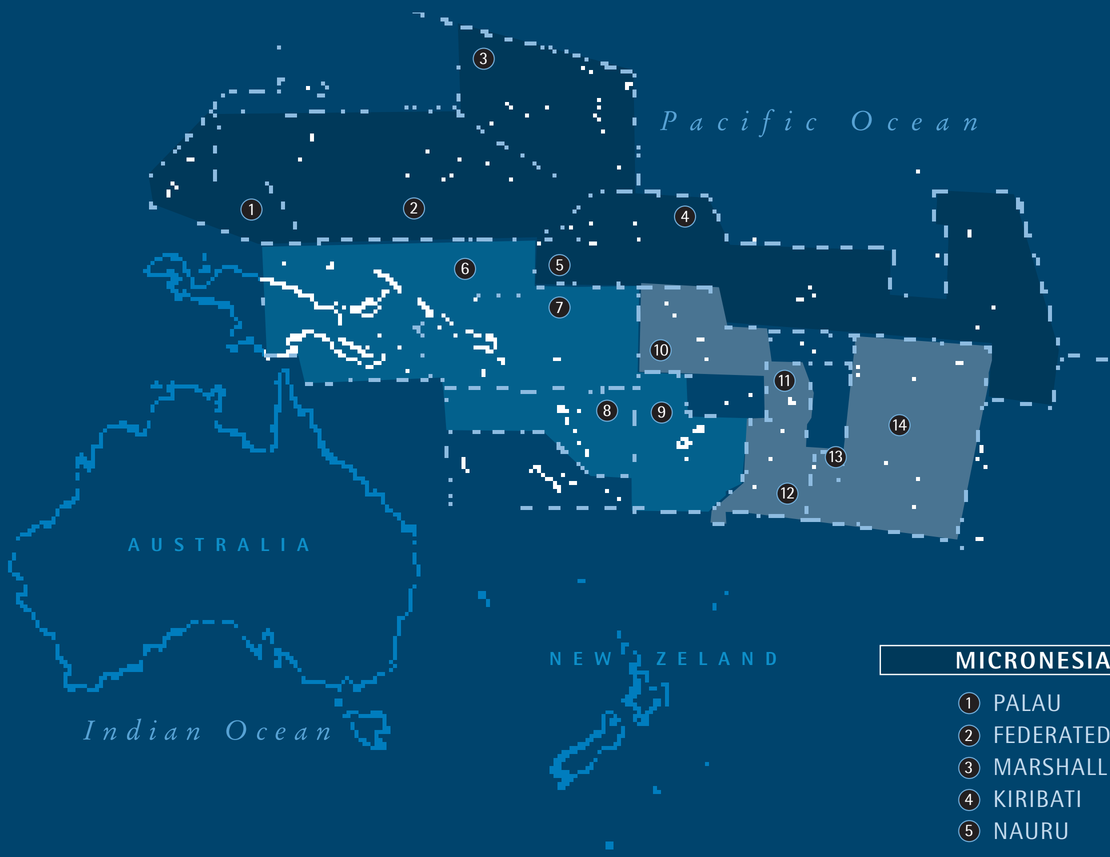
MAP OF PACIFIC ISLAND COUNTRIES(*)



0 800 1 600 2 400

Kilometers

MICRONESIA

1. PALAU
2. FEDERATED STATES OF MICRONESIA
3. MARSHALL ISLANDS
4. KIRIBATI
5. NAURU

MELANESIA

6. PAPUA NEW GUINEA
7. SOLOMON ISLANDS
8. VANUATU
9. FIJI

POLYNESIA

10. TUVALU
11. SAMOA
12. TONGA
13. NIUE
14. COOK ISLANDS

(*) FAO MEMBER COUNTRIES

INTRODUCTION

What is the purpose of this toolkit?

This *Food Security Toolkit*, designed specifically for Pacific Island Countries and Territories (PICTs), aims to improve Pacific Islanders' ability to produce and access safe and nutritious foods that meet their dietary and cultural needs. Targeting food security in the Pacific region is a critical action in the face of climate change, which will continue to place added pressure on existing food and water resources. The ultimate aim of the toolkit is to help ensure that Pacific Island communities continue to produce and have access to a wide range of nutritious food for the dinner plate and market place.

How to use this toolkit?

The toolkit is divided into a series of modules, so as to accommodate future changes or additions. It includes an introductory module that looks at climate change in the Pacific, a module on key Pacific food production systems and two applied modules on Pacific root crops and Pacific fisheries.

The toolkit also contains 55 "adaptation steps" that are designed to provide ideas and, in some cases, practical measures that can be used and, with time, adapted to help maintain and strengthen food security in the face of climate change. Importantly, the toolkit provides its readers a list of existing tools and resources that present more detailed information on climate change adaptation measures, food security and related issues.

Who is the target audience?

Tackling food security and climate change in the Pacific region requires the development or implementation of integrated strategies, policies and practices that reach all levels of Pacific society. It also requires a strong collaborative and cross-sectoral approach from regional organizations, national governments, and urban and village leaders, as well as individual farmers and fishers. The toolkit is, accordingly, broadly focused and provides both adaptive steps for PICT government agencies and practical steps designed to improve sustainable management and production practices at the community level. The toolkit has been written for a broad audience that may include: government officials; national agriculture, forestry and fisheries development officers; non-governmental organizations (NGOs); community groups; and other stakeholders within the agriculture and fisheries sectors.

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module **1**

CLIMATE CHANGE

1.0 WHAT IS CLIMATE CHANGE?

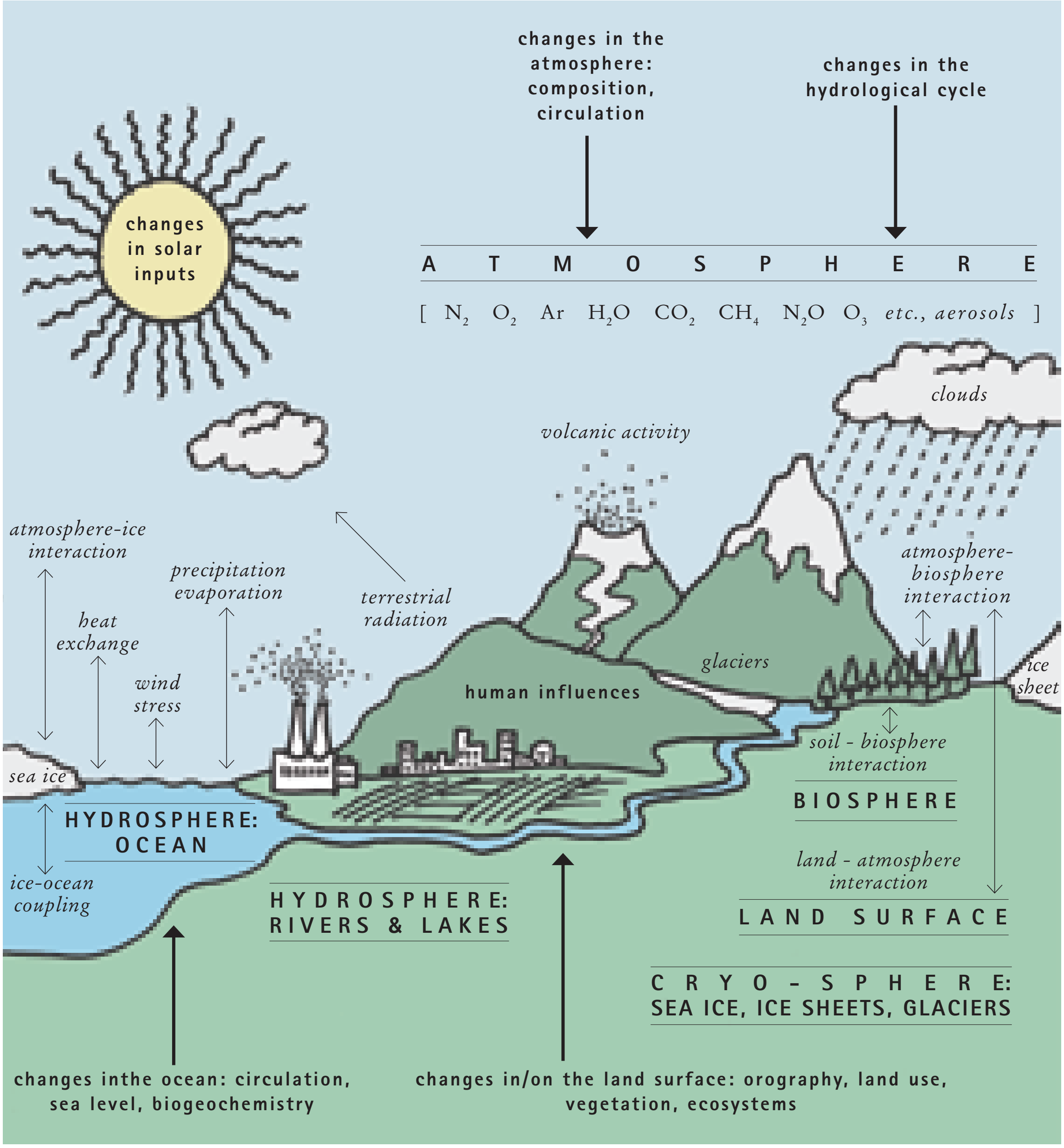
The Earth has gone through many natural cycles of warming and cooling during its long history and has always been subject to climate variability that brings about droughts, flooding and extreme weather patterns. Now, scientists have confirmed that the Earth's atmosphere and oceans are warming gradually as a result of human activity. This warming will exacerbate climate variability and, ultimately, will adversely impact food and water security around the planet. Central to global warming is the "*greenhouse effect*" – a process in which greenhouse gases in the Earth's atmosphere trap some of the Sun's energy and warm the planet. While the greenhouse effect plays a crucial role in warming the Earth to support life[1], over the past 100 to 200 years the concentrations of human-made (anthropogenic) greenhouse gases in the Earth's atmosphere have increased significantly as a result of industrial activity, deforestation and the burning of fossil fuels such as coal and oil (Figure 1.1 & 1.2).

Scientists are concerned that climate change is happening so quickly that most natural ecosystems are in serious danger of collapsing – they simply can't adapt quickly enough to the changing environmental conditions. Climate change has serious implications for all nations but many developing nations are especially vulnerable because they are highly dependent on natural ecosystems for their livelihoods and as sources of food, water and shelter. Many developing countries are also located in regions around the globe that will be most strongly impacted by climate change. Furthermore, they tend to lack the resources to implement adaptation measures or to build resilience by, for example, diversifying food production systems and livelihoods.

(See TOOLS 6-18 for more about climate change and its causes.)

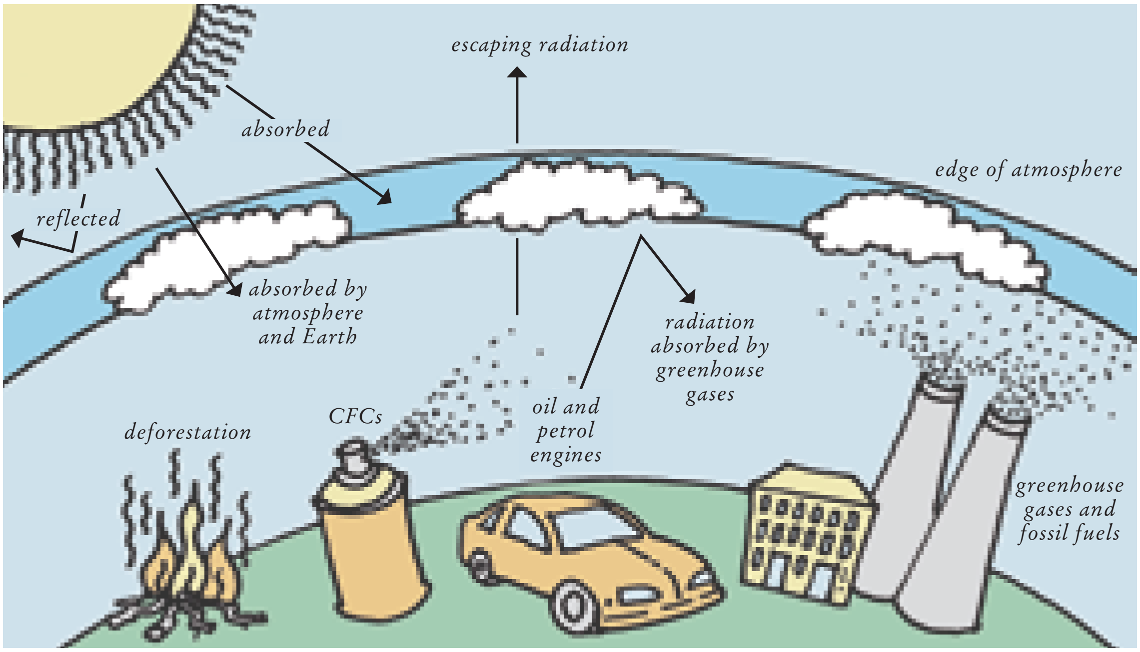
1 Without the natural greenhouse gas effect, the Earth's mean temperature would be a very chilly -18ºC.

Figure 1.1: **Schematic view of the components of the global climate system (bold upper case), their processes and interactions (thin arrows) and some aspects that may change (bold arrows).**



Source: IPCC Third Assessment Report, 2001.

Figure 1.2: **Schematic diagram of key climate change mechanisms.**



1.1 WHAT IS THE GREENHOUSE EFFECT?

- Incoming solar radiation from the Sun hits the Earth's atmosphere.
- About 30 percent of this incoming radiation is reflected back into space by clouds, ice, snow and other bright surfaces.
- The remaining energy passes through a "blanket" of gases that surrounds the Earth.
- As the Sun's energy reaches the Earth's surface, much of it is absorbed by the planet's land, water and biosphere.
- Most of this energy is eventually radiated back into space as long-wave radiation, but some of it becomes trapped in our atmosphere by greenhouse gases, including water vapor, carbon dioxide and methane.
- This phenomenon is known as the "greenhouse effect" which is essential to life on Earth as we know it. Without it, the Earth would be a very chilly minus 18°C.

- Unfortunately, human activity (e.g. the burning of fossil fuels and forest clearing) is releasing large volumes of human-made or "anthropogenic" greenhouse gases into the atmosphere. This is enhancing the greenhouse effect and causing the Earth's climate and oceans to warm, slowly but surely.
- Many people confuse the greenhouse effect with the "ozone hole". These are two entirely different processes and only one leads to global warming – the greenhouse effect!

1.2 WHAT WILL BE THE IMPACTS OF CLIMATE CHANGE IN THE PACIFIC?

While there is still some uncertainty surrounding the exact nature and timelines of climate change in the Pacific region, the world's leading scientists agree that PICTs are highly vulnerable to the impacts of climate change. These changes, already impacting some Pacific nations, include: *rising ocean levels; ocean warming and acidification; changing precipitation patterns; changing cloud cover; altered ocean and atmosphere circulation patterns; increased intensity and possibly frequency of extreme weather events including tropical cyclones, floods and droughts*. Table 1.1 indicates widely accepted projections for some key climate change parameters in the Pacific region over the next 60 to 90 years.

Table 1.1: Climate change projections for Pacific region

Surface air temperature increases of 1.0 to 4.17°C in the northern Pacific by 2070-2099
Surface air temperature increases of 0.99 to 3.11°C in the southern Pacific by 2070-2099
Sea surface temperature increases by 1.0 to 3.0°C by 2070-2099
Ocean waters acidify by 0.14 to 0.35 units by 2099
Sea-level rise of 0.18 to 0.59m by 2099
Rainfall decreases or increases from -2.7% to +25.8% in the northern Pacific by 2070-2099
Rainfall decreases or increases from -14% to +14.6% in the southern Pacific by 2070-2099
Possible increases in the intensity of extreme weather events including droughts, floods and tropical cyclones which may exhibit higher increased peak wind speeds and rainfall

Source: IPCC Fourth Assessment Report, 2007 (See TOOLS 8 & 9.)

1.3 HOW WILL CLIMATE CHANGE IMPACT FOOD SECURITY IN THE PACIFIC?

Many of the physical impacts of climate change are closely interrelated and will negatively impact food security in PICTs. These impacts may include*: salinization (salt accumulation) of soils and water resources from salt spray and rising ocean levels; soil erosion; spread of plant diseases, pests and invasive species; increased frequency of forest fires due to drought; land and marine ecosystem degradation by intensified tropical storms; and, of course, the inundation (flooding) of low-lying arable land by the sea and swollen rivers.* These impacts are likely to result in many changes to PICT ecosystems and will ultimately change the way in which Pacific Island peoples hunt, gather and grow their food.

In light of these changes, it is imperative that Pacific Islands are adequately prepared for climate change. Ensuring that people have continuous access to nutritious food in times of change is not a simple task. It will require a carefully planned and managed approach to protect existing natural resources and to improve the sustainability of current agricultural, forestry and fishing practices. (See TOOLS 1-5 to find out how climate change is likely to impact the region's food security.)

1.4 HOW DO WE STOP CLIMATE CHANGE?

While Pacific Island countries are responsible for very little (0.03 percent) of the CO_2 and other greenhouse gases entering the Earth's atmosphere, our everyday energy use and the way we manage our environment is still contributing to the build-up of CO_2. For example, every time we cut down a tree for firewood, drive a car, watch TV or cook a meal, we are either directly or indirectly releasing CO_2 into our atmosphere. "*Mitigating climate change*" is all about trying to minimize the amount of greenhouse gases we release into the atmosphere. Alternatively, we also can mitigate climate change by capturing and storing greenhouse gases through activities such as planting trees or by promoting the buildup of organic matter (humus) in soils.

In Pacific Island countries, the main way we can help mitigate climate change is to reduce our use of fossil fuels, such as diesel and petrol, and ensure that we sustainably manage our forests[2]. These actions will not only help global efforts to halt climate change but will also serve to protect our natural environment, and may even save a family money that would have otherwise been spent on fuel and/or electricity. Using sustainable agricultural practices and constructing energy-efficient buildings are other ways we can reduce greenhouse gas emission rates in the Pacific. When PICTs take such steps to cut greenhouse gas emissions, we send a strong message to industrialized countries that they too need to reduce their own greenhouse gas emissions. Basically if we can demonstrate that we can cut our greenhouse gas emissions, it puts pressure on industrialized nations and other developing countries to cut their own emissions too!

Here are some simple steps that you and your family can take to help reduce greenhouse gas emissions and hopefully save some money at the same time.

1.4.1 Checklist of simple mitigation steps

~ **Natural lighting:** Whenever practical, use natural lighting from windows and doors to light your house... it is totally free!

~ **Energy efficient light bulbs:** Replace incandescent light bulbs (old-style round bulbs) with efficient, low-wattage compact fluorescent lights (CFLs). While CFLs may cost more to buy, they can last much longer and use far less power... saving you money in the long run.

~ **Cooling your home:** Windows and doors can provide natural ventilation when it's hot. This will reduce the need for air-conditioning units and fans. Air-conditioners are the most energy-hungry of home appliances, so avoid using them whenever you can. If you have to use one, set the thermostat as high as possible (warmer) and keep the windows and doors closed.

2 Trees mitigate climate change by absorbing CO_2 as they grow. So by planting more trees and protecting existing forests, Pacific Island countries can help fight climate change.

~ Be paint wise: Use reflective light-coloured paints on both the inside and outside of your homes and buildings to reduce lighting and cooling requirements on the inside.

~ Insulating your home: Installing insulation in your roof cavity and shading windows can also help keep houses cool in summer and warm in winter. It can also reduce the need to run electric fans, air-conditioning units and heaters, thus saving you money and helping mitigate climate change.

~ Switching off: Ensure that you switch off lights and appliances at the wall when you are not using them, as many appliances such as TVs and DVD players still use electricity even when they are in standby mode.

~ Clothes drying: Hang your clothes out to dry rather than relying on energy-hungry clothes dryers.

~ Solar power: More and more people heat water and generate electricity by using natural and abundant solar energy. The Sun's energy can provide an excellent way to obtain cheap electricity and hot water for your household or business.

~ Leaking taps: Be sure to fix leaking taps and pipes. These don't just waste precious water resources but electricity too that is used pump and purify water.

~ Appliance settings: Use energy efficient settings on electrical appliances such as washing machines, and be sure to increase thermostat settings on air-conditioning units to save on energy.

~ Consumer power: When buying a car or household appliance, look for the most energy-efficient option available to reduce carbon emissions and running costs. Some appliances have "star" ratings, so look for the appliance with the highest star rating.

~ **Transport:** Using public transport, sharing lifts, leaving the car at home and biking or walking are all ways in which we can reduce carbon emissions and save money! Biking and walking are also great ways of staying healthy and keeping in shape!

~ **Recharge your batteries:** Rechargeable batteries are a cheaper option in the long run for your household and are much better for the planet. Switching to rechargeable batteries for radios, torches and toys will save on carbon emissions and money, and also reduce the toxic waste going into Pacific Island landfills.

~ **Recycling:** Find out what materials can be recycled in your country (e.g. plastic bottles, cans and cardboard), and start storing and recycling these materials now. You may be able to recycle more than you think!

~ **Packaging:** When buying food and other products, try to buy locally produced products and certainly avoid highly packaged products that don't have reusable or recyclable packaging.

~ **Plastics:** Remember that most plastics are not readily biodegradable (they don't break down easily when buried in landfills) so try to avoid using plastic bags and Styrofoam cups and containers whenever possible to help reduce greenhouse gas emissions.

~ **Other steps:** Many of the tools and resources outlined in this "food security toolkit" will provide further examples of how you and your family can help mitigate climate change. Activities from growing your own organic vegetables to conserving forest trees all can help improve our access to nutritious, tasty and affordable food while at the same time help to protect our environmental resources and reduce carbon emissions.

(See TOOLS 6, 7, 11 & 14 to find out more about climate change mitigation.)

1.5 WHAT IS THE REST OF THE WORLD DOING?

Over the past few decades, growing understanding and concern about the pending environmental and socio-economic impacts of climate change have prompted international action on climate change and the search for effective adaptation and mitigation measures. In 1988, the *Intergovernmental Panel on Climate Change* (IPCC) was established to evaluate the risk of climate change caused by human activity. The IPCC does not carry out its own research, nor does it monitor climate change or related phenomena itself, but rather it analyses research and published literature to produce special reports on topics relevant to the implementation of the *United Nations Framework Convention on Climate Change* (UNFCCC). These reports are widely cited by the international community and provide information on issues ranging from climate change projections to community-based adaptation measures. (See TOOLS 8 & 9.)

The UNFCCC was established by the United Nations General Assembly in 1992. It is an international environmental treaty that broadly aims to stabilize concentrations of greenhouse gasses in the Earth's atmosphere to prevent dangerous climate change. In an attempt to introduce a mechanism to encourage industrialized countries to cut their greenhouse gas emission rates and meet the objectives of the UNFCCC, the signatories to the treaty established the *Kyoto Protocol*. The Kyoto Protocol, which came into effect in February 2005, established emission reduction targets for 37 developed countries (known as Annex 1 countries) and commited them to cutting collective greenhouse gas emissions by about 5 percent from the 1990 level.

One of the shortcomings of the Kyoto protocol is that it fails to place any binding emission reduction targets on developing countries such as China, India and Brazil who have become major greenhouse gas emitters. In fact, China has now surpassed the USA as the world's major emitter of greenhouse gases and notably neither of these countries has agreed to recommended, or in the case of the USA, binding greenhouse gas emission cuts outlined in the Kyoto Protocol. On the other side of the coin, there is no arguing that developed nations, through their present and historic emissions, have set climate change in motion and must lead global efforts to cut greenhouse gas emission rates substantially.

In late 2009, parties to the UNFCCC met in Copenhagen, Denmark, to try to agree upon a *post-Kyoto Protocol*. Because the meeting failed to reach any legally binding emissions targets for either developing or industrialized nations, hope turned to the 2010 UNFCCC Conference of Parties (COP16) meeting in Cancún, Mexico. Post-Cancún, there is little doubt that substantive funding will come on stream within the next few years to support mitigation and adaptation initiatives around the world, and particularly those within developing countries. (See TOOLS 1-21 to find out more about global efforts to combat climate change.)

1.6 WHAT IS CLIMATE CHANGE ADAPTATION?

As the world battles to reach consensus and take action on reducing greenhouse gas emissions, scientists widely acknowledge that historic (and ongoing) greenhouse gas emissions have locked the Earth into some degree of warming over the next century or more. In other words, a certain amount of climate change will happen regardless of what actions are taken today to reduce emissions. Some PICTs are already thought to be feeling the initial impacts of climate change, which are predicted to intensify with time.

To avoid the most damaging impacts of climate change, PICTs must ensure they implement a variety of climate change adaptation measures. These measures include actions designed to reduce the vulnerability of natural and human systems to actual or expected climate change impacts. Most adaptation steps being implemented now within the Pacific region are responding to current climate trends, climate variability and broader environmental degradation. An example of this type of “reactive adaptation" would be the installation of seawalls to curb intensifying shoreline erosion in some low-lying coastal villages. There are also examples of "anticipatory adaptation" being implemented in the region. This type of adaptation focuses on "anticipating" and reducing the impacts of future climate change. For example, the work being undertaken in the Cook Islands to "build back better" following the devastating impacts of Cyclone Pat in February 2010 is based on the recognition that coastal communities are highly vulnerable to storm surges and cyclones – phenomenon that may intensify as a result of climate change.

The ability of any country to adapt to and cope with climate change depends on numerous factors, such as the country's sociopolitical will and access to monetary resources, technical knowhow, skilled trades-people and effective managers. Developing nations, and particularly the poor within developing nations, tend to be the most reliant on natural ecosystems for their livelihoods, and typically have fewer monetary and other resources at hand.

Accordingly, they are most vulnerable to climate change and other socio-economic stresses such as population growth, urbanization, resource degradation and fluctuating commodity prices. Policies that lessen pressures on natural resources, improve management of environmental risks, and increase the welfare of the poorest members of society can advance sustainable development and equity, enhance adaptive capacity and ultimately reduce vulnerability to climate change and other stresses.

While this toolkit focuses on food security as a means of building resilience to climate change, there are numerous other types of adaptation measures that can be taken to reduce the impacts of climate change. The following list includes examples of key adaptation measures.

1.6.1 Examples of climate change adaptation measures by sector

- **Infrastructure development:** Relocating existing buildings and constructing seawalls, surge barriers and windbreaks are examples of common adaptation measures.

- **Energy:** Strengthening energy generation and distribution infrastructure, improving energy efficiency practices and diversifying sources of energy are a few of the adaptation measures available to the energy sector.

- **Food security:** Ensuring that Pacific Island peoples have ready access to safe, nutritious and culturally appropriate food is of critical importance to the continued development and stability of the Pacific region. This is predicted to become increasingly challenging as climate change takes hold. Adjusting planting dates; relocating crops; promoting the use of drought/salt tolerant crop varieties and low-input organic agriculture; improving food processing and distribution networks; conserving coral reefs and coastal ecosystems; and increasing the volume of intraregional trade are just a few of the many measures that can be used to improve food security and build resilience to climate change within the Pacific region.

- **Human health:** Improving the monitoring and control of climate-sensitive diseases and heat-related illness, and improving water and sanitation will be vital adaptation measures for PICTs.

- **Tourism:** The tourism industry is the economic backbone of many Pacific Island nations and is likely to be adversely impacted by climate change. Diversification of tourist activities and reduced reliance on coastal infrastructure and resources will help build resilience to climate change within this industry.

- **Transport:** Relocation and realignment of existing roads, rail and airport infrastructure, and the use of improved design standards and construction techniques will be required to address issues such as increased rainfall, wind speeds and sea levels.

- **Water security:** **Climate change is predicted to change rainfall patterns substantively in the Pacific region. While some countries may become more drought prone, others may receive more intense rainfall events. These changes are likely to lead to an overall reduction in crop yields and, when combined with sea-level rise, are likely to reduce potable water supplies in many PICTs. Efforts to protect rainfall catchments and existing water resources; expand water harvesting; and improve water storage, irrigation and conservation practices will become increasingly important adaptation measures for all PICTs.** (See TOOLS 11-21 to find out more about climate change adaptation measures.)

1.7 HOW IS THE REGION COMBATING CLIMATE CHANGE?

Pacific Island leaders have been at the forefront of climate change developments over the past few decades and have been instrumental in highlighting the vulnerability of Pacific Island nations to the broader global community. In recent years, Pacific leaders developed several communiqués including the "Niue Declaration on Climate Change" and also guided Council of Region Organisations in the Pacific (CROP) agencies to develop the "2005 Pacific Islands Framework for Action on Climate Change" and its associated implementation plan that was finalized in 2008 (See TOOLS 20 & 21).

The establishment of the GEF Least Developed Country Fund in November 2002 saw funds allocated to the Pacific region's Least Developed Countries (Kiribati, Samoa, Solomon Islands, Tuvalu and Vanuatu) to aid them in their preparation of National Adaptation Programmes of Action (NAPAs). Within the NAPA process, each of these countries has identified priority climate change adaptation projects that are eligible for GEF funding. Other developing PICTs within the region are now calling for similar support to be made available to non-LDCs, so that they too have the resources required to map out vulnerabilities, and plan and implement country-specific measures to combat climate change.

Although the UNFCCC has agreed in principal to broaden the NAPA process to include non-LDCs, the decision has not yet been formalized by the UNFCCC's Conference of Parties. This has not deterred PICTs and development partners from commencing a wide range of climate-change related initiatives throughout the region. Gap analysis work carried out by the United Nations System in 2009 indicates that PICT Governments, bilateral and multilateral donors, civil society organizations (CSOs) and international financial institutions are involved in more than 270 initiatives in the Pacific region that either directly or indirectly address climate change mitigation or adaptation. Major stakeholders in the region include: PICT governments; CROP agencies[3]; the Governments of Australia, Canada, Italy, Germany, Japan, New Zealand and Sweden; various CSOs and NGOs; the Asian Development Bank and the World Bank; the European Union; the Global Environment Facility (GEF); and the many UN System agencies.

Many of the climate change adaptation initiatives being carried out in the Pacific region have a food security component to them (Table 1.2). The major players in this field are FAO and the SPC, and to a lesser extent, the EU, GTZ, IFAD, SOPAC, UNDP and AusAID (see footnote 4). Much of the work being carried out by FAO and SPC is relatively small-scale project-based work designed to improve agricultural production, sustainable livelihoods and ultimately food security. FAO has been particularly active through its TeleFood Project and Regional Programme for Food Security (RPFS), and has also carried out considerable preparatory work towards its new Food Security and Sustainable Livelihoods Programme (FSSLP).

Another major initiative that includes a food security focus is the Pacific Adaptation to Climate Change Project (PACC) that is being managed by the Secretariat for the Pacific Regional Environment Programme (SPREP). This regional project involves

3 CROP agencies include the: Forum Fisheries Agency (FFA), Pacific Islands Forum Secretariat (PIFS), Secretariat of the Pacific Community (SPC), South Pacific Applied Geoscience Commission (SOPAC), South Pacific Tourism Organisation (SPTO), University of the South Pacific (USP), Secretariat of the Pacific Regional Environment Programme (SPREP), Pacific Islands Development Programme, Fiji School of Medicine (FSM), and the South Pacific Board for Educational Assessment. Other donor organizations include European Union (EU), German Technical Cooperation (GTZ), International Fund for Agriculture and Development (IFAD), United Nations Develop Programme (UNDP) and Australian Agency for International Development (AusAID).

13 Pacific Island countries and is one of the few projects to access the Special Climate Change Fund of the GEF globally. The objective of the US$13.1 million PACC is to enhance the resilience of a number of key development sectors – such as food production and food security, water resources management, coastal zone and infrastructure – in PICTs to the adverse effects of climate change (Table 1.2).

Table 1.2: **A small selection of ongoing and recently completed food security initiatives in the Pacific**

TITLE	SELECTED REGIONAL FOOD SECURITY INITIATIVES	LEADS & STATUS	SCOPE
AGRICULTURE AND FOOD SECURITY	AusAID has numerous agricultural and crop development activities thoughout the Pacific region that have clear spin-offs for food security in the region. Several examples specifying a food security focus are included below.		regional
AUSAID-"AGRICULTURAL RESEARCH AND DEVELOPMENT SUPPORT FACILITY (ARDSF)"	AusAID is providing funds (2006 to 2011) to the Government of PNG through the Agricultural Research and Development Support Facility (ARDSF). ARDSF is strengthening the capacity of PNG's primary agricultural research and commodity institutions to deliver improved services to their rural stakeholders, as well as to provide additional resources through a competitive grant scheme to support the testing and promotion of innovations that will have a positive impact on the livelihood of smallholder farmers. Improved services will increase opportunities for small-holder farmers to improve productivity and market competitiveness and strengthen farmer incomes and food security.	AusAID 2011	PNG
AUSAID-ACIAR	AusAID provides US$2 million annually to the Australian Centre for International Agricultural Research (ACIAR) to facilitate research partnerships into key agricultural research areas in PNG such as reducing pest impacts and the management of fruit fly and potato late blight. Since 1998, AusAID has contributed US$18.6 million to this programme that is aimed at increasing farmers' incomes and strengthening food security.	AusAID Ongoing	PNG
REHABILITATION OF THE FIJI AGRICULTURE SECTOR DAMAGED DURING CYCLONE GENE	Funds provided to the Government of Fiji for the rehabilitation of its agriculture which was damaged during Tropical Cyclone Gene in January 2008. Australian funds contributed to crop rehabilitation – mainly through the provision of planting materials – in 12 of Fiji's 14 provinces, where around 51 000 farmers were affected.	AusAID 2008	Fiji

TITLE	SELECTED REGIONAL FOOD SECURITY INITIATIVES	LEADS & STATUS	SCOPE
COUNTRY ASSESSMENTS ON THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY IN THE PACIFIC	Field studies to determine the potential impact of climate change on agriculture and food security in selected Pacific Island countries. Studies, carried out by independent FAO consultant on RMI, Vanuatu and Cook Islands, have been completed.	FAO Ongoing	Regional
DEVELOPMENT PARTNERS MAPPING EXERCISE	Regional study undertaken to map development partners and their activities in the area of Food Security and Sustainable Livelihoods in the Pacific Island Countries.	FAO 2008	Regional
SUPPORT TO THE REGIONAL FOOD SECURITY PROJECT IN THE PACIFIC ISLAND COUNTRIES	Italian-funded Regional Programme for Food Security (RPFS) in the Pacific Island Countries contributes to the stabilization of food security, both at national and household levels in the developing country members of the Pacific Islands Forum. The programme has two main components: (1) enhancing food production and security through investing in specific production-related (supply side) activities, and (2) strengthening agricultural trade and policy. There are 26 national projects in the 14 Forum island countries.	FAO/Italy 2003-ongoing	Regional
TELEFOOD PROJECTS	Grassroots-level projects to assist poor families in improving their means of production, enabling them to produce more food, and to generate cash income which will allow them better access to food. Includes assistance in the area of crop production, small animal & fish production; and value adding. Activities in Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Niue, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu	FAO 2003-ongoing	Regional
FOOD SECURITY AND SUSTAINABLE LIVELIHOODS PROGRAMME (FSSLP)	The FSSLP has three main components: (1) enhancing food production and income generation at national level, (2) trade facilitation and harmonization, and (3) investment in infrastructure. It addresses agricultural productive supply constraints such as access to inputs, extension services, improved agricultural information availability and dissemination and improved market infrastructure. IFAD fielded a mission to participate in the design of the FAO FSSLP.	FAO/IFAD Pipeline	Regional
CENTRES OF EXCELLENCE FOR RESEARCH AND DEVELOPMENT OF ATOLL AGRICULTURE	This project, implemented by the SPC Land Resource Division supports documentation and promotion of traditional food production, preparation and preservation, was designed to undertake action research and extension activities to address issues such as poor soil, irrigation and limited resource base of coral atolls.	IFAD/GTZ/SPC 2008-2010	Subregional (based in Kiribati & RMI)

TITLE	SELECTED REGIONAL FOOD SECURITY INITIATIVES	LEADS & STATUS	SCOPE
SPC CLIMATE READY CROPS – ADAPTATION TO CLIMATE CHANGE	Establishment of a "climate ready" collection consisting of crops and varieties with specific traits such as drought and salt tolerance as well as those crops and varieties known to tolerate other marginal growing conditions.	SPC Pipeline	Regional
PACIFIC ADAPTATION TO CLIMATE CHANGE PROJECT (PACC)	This regional project involves 13 Pacific Island countries and is one of the few global projects to access the Special Climate Change Fund of the GEF. The objective of the US$13 million PACC is to enhance the resilience of a number of key development sectors (food production and food security, water resources management, coastal zone, infrastructure etc.) in the Pacific Islands to the adverse effects of climate change. Various projects are planned for Solomon Islands, PNG, Palau and Fiji that will focus on water and food security (irrigation, drainage, and coastal food production systems).	SPREP/ UNDP Ongoing	Regional
INTEGRATED CLIMATE CHANGE ADAPTATION PROJECT FOR SAMOA	The project implements the remaining and most urgent adaptation priorities in Samoa's National Adaptation Programme of Action (NAPA), namely climate early warning systems, climate agriculture and food security, and climate-sensitive diseases. The objective is to increase the resilience and adaptive capacity of coastal communities in Samoa to the adverse impacts of climate change on agricultural production and public health through improved early warning systems. It also address the PACC SPREP Project and FAO.	UNDP 2008-2012	Samoa

1.8 THE IMPACTS OF CLIMATE CHANGE ON PACIFIC FOOD SYSTEMS

While there is still significant uncertainty surrounding the exact nature, magnitude and timelines of climate change in the Pacific region, there is no doubt that PICTs are highly vulnerable to the present and pending impacts of climate change and climate variability. The agriculture sectors in PICTs are particularly vulnerable given their heavy reliance on a wide range of natural ecosystem services such as soil fertility, insect pollination and the maintenance of soil moisture levels through rainfall, to name but a few. These ecosystem services are highly interrelated and strongly dictated by prevailing climatic regimes. Therefore, long-term changes to rainfall, temperature, and soil and air-moisture regimes will impact agricultural yields and the distribution and types of crops that can be grown in PICTs.

Although there is some evidence to suggest that higher carbon dioxide levels in the atmosphere may actually encourage the growth of some crop species, it is widely accepted that the overall impact of climate change on crop production in the Pacific will be negative.

These overall crop production losses are anticipated due to a combination of factors which are summarised in Table 1.3.

Table 1.3: **Summarised impacts of climate change on soil resources and crop production**

Possible intensified cyclone and storm activity	→	Soil erosion and nutrient depletion, crop and infrastructural damage
Rising sea levels and increased salt spray	→	Seawater inundation of land and soil salinization
Rapidly changing environmental parameters and ecosystems	→	Proliferation of new and existing invasive pests and diseases
Changing rainfall patterns	→	Increased incidence of drought and/or flooding

In the case of tropical root crops, as with some other agricultural crops, many species are already considered to be growing in conditions close to their maximum heat tolerance, which means even a small amount of warming combined with rainfall changes may result in substantive decreases in crop yields. The impact of climate change on production levels will not be uniform across the Pacific region. Rather, it will vary from country to country on account of PICT's different geophysical attributes (e.g. *geographical location; height above sea level; and extent and fertility of existing soil and land resources*) and of course various socio-economic factors (e.g. *human and financial capacity to plan and prepare for climate change*).

Accordingly, larger and resource-rich islands such as Papua New Guinea and Viti Levu in Fiji, may expect comparatively smaller impacts to their crop production than atoll countries, such as Kiribati, which are low-lying, have very limited soil and water resources, and also face the grim reality of losing large tracts of agricultural land to sea-level rise and soil salinization. In saying this, it is important to note that while climate change may have lower impacts on crop production on some of the larger Pacific Islands, these same islands host larger populations and, ultimately, the severity of climate change impacts are likely to lie in the way that individual countries "climate-proof" (i.e. plan and prepare) their agricultural sectors for the future. (See TOOLS 1-5.)

1.8.1 Changing water regimes

Rainfall is one of the most important crop production parameters. Unfortunately future rainfall projections for the Pacific region are fraught with uncertainty and even the direction of the rainfall change at the sub-regional level is poorly understood (Table 1.1).

The difficulty scientists face in predicting future rainfall pattern changes in the Pacific region is due to the complex interaction between the various marine and atmospheric systems that dictate weather and climate. The primary drivers of rainfall in the Pacific region include the warming of the atmosphere and oceanic waters, the Inter-Tropical Convergence Zone (ITCZ), the South Pacific Convergence Zone (SPCZ), and the El Niño Southern Oscillation (ENSO). However, numerous other wind and water currents drive seasonal rainfall and weather patterns over the vast Pacific Ocean.

Such a high level of uncertainty of how rainfall patterns will change in the Pacific region is very concerning given that many PICTs are heavily reliant on rain-fed agricultural production and rainfall as a source of drinking water and recharge for aquifers. The stark reality is that even minor changes in rainfall volumes and patterns will have potentially dire consequences for crop production, and food and water security for many PICTs within the Pacific region.

1.8.2 Storms and cyclones

In the Pacific region, there is some evidence to suggest that storm and tropical cyclone activity will intensify as the atmosphere and Pacific Ocean continue to warm. The ENSO, which strongly dictates the development and distribution of cyclones within the Pacific region, will be affected by warming air and ocean temperatures, which essentially "fuel" the development of cyclones.

In a warmer Pacific region, some PICTs in the central and eastern Pacific may become impacted more frequently by higher intensity storms and tropical cyclones if El Niño-like spatial patterns begin to dominate as some researchers predict. Given that many Pacific Islands lie no more than a few metres above sea level, the combined impact of tropical cyclones, storm surges and sea-level rise are of extreme concern, particularly for low-lying atoll nations such as Kiribati, RMI and Tuvalu.

Powerful winds, intense rainfall, and storm surges from tropical cyclones and severe storms have the ability to devastate crops; down trees, fences and farm buildings; and to inundate, erode and leach low-lying agriculture soils in coastal areas and stream catchments. The damage wrought by cyclones (Rene, Tomas, Ului) that hit Fiji, Tonga, Samoa and neighbouring countries in early 2010 are testament to the ferocity of the these extreme weather events and the damage they can unleash on crops and infrastructure. (See TOOLS 8-10)

1.8.3 Drought and fire

On the other end of the rainfall spectrum from cyclones is drought and, unfortunately, the frequency and intensity of droughts may also increase in some PICTs as the atmosphere and oceans continue to warm. As with cyclones, droughts can have a devastating effect on crop production. The ravage of drought, felt in many PICTs in the past few decades, is possibly best exemplified by the

El Niño-induced drought that struck Fiji in 1998. This drought decimated about 40 percent of the country's sugar cane crops and directly impacted the livelihoods of an estimated 28 000 households.

In addition to the direct impacts of drought on crop production, drought also substantially increases the risk of fire that has the potential to destroy crops, forests and agricultural infrastructure, such as farm buildings, machinery, fences and shelter belts. Accordingly, many of the impacts of fire on agricultural production can be catastrophic and financially crippling to farmers.

1.8.4 Crop inundation and soil salinization

In many PICTs, large areas of arable land tends to be concentrated on low-lying coastal plains or within the lower reaches of river and stream catchments. These lands are typically vulnerable to flooding, storm surges and longer term sea level rise and are certainly likely to be further compromised by the impacts of climate change as they take hold in the region.

While low-lying atoll nations such as Kiribati, RMI and Tuvalu will be most vulnerable to rising sea levels, every PICT will be seriously impacted by rising ocean levels. Many larger islands, such as Tongatapu in Tonga, can expect to see large tracts of low-lying arable land lost to the rising Pacific Ocean over the next 100 years.

1.8.5 Invasive species, pests and diseases

The establishment of new and/or existing pests and diseases represents some of the most serious, but poorly understood, risks to agricultural production in PICTs. Pacific Islands are particularly vulnerable to invasive species because of their isolation and relatively recent human occupation. Pacific island species have not evolved to cope with the impacts of predators, herbivores, insect pests, highly competitive weeds and diseases bought in from continental areas and neighbouring islands. Examples of invasive species present in the region include types of: *vertebrate animals (e.g. rats, goats, cats, mongooses and myna birds etc.), invertebrate pests (e.g. snails, slugs, nematodes, mosquitoes, beetles and other insects), weeds (e.g. trees, vines, shrubs and grasses) and other soil, plant and animal pathogens (e.g. fungi, bacteria, and viruses).* These invasive species can affect agriculture, aquaculture, fisheries and forestry sectors and are responsible for the extinction of more island native species than any other cause.

The complex interactions that govern the population dynamics and proliferation of invasive species, pests and diseases make it extremely difficult for scientists to predict how they may impact food production systems under the various climate change scenarios. Scientists are confident, however, that as the Pacific climate becomes warmer and rainfall patterns change, many crops will become stressed and more susceptible to pest and disease outbreaks. In a warmer climate, other currently benign pest and diseases may also rise to the fore as delicate ecological balances are disturbed and ecological ranges change.

While not believed to be attributable to climate change per se, the taro leaf blight (*Phytophthora colacasiae* Racib), a fungal plant disease that devastated Samoa in the early 1990s, provides a graphic example of the devastating impacts that disease can have on crop yields. Within a year of the blight's establishment in 1993, Samoan taro exports fell to less than 2 percent of pre-blight levels and more than 15 years later the taro export industry in Samoa has yet to fully recover. A similar outbreak of TLB seriously undermined food security in the Solomon Islands after World World II and resulted in a permanent shift in some parts of the country away from taro to sweet potato and cassava production. Just how TLB and other diseases and crop pathogens (e.g. taro beetle, taro soft rot, and taro viruses) will impact the region's taro industry remains a matter of much conjecture, but it will be clearly linked with climate change and long-term food security within the region. (See TOOLS 47 & 48 for further information on combating invasive species.)

1.8.6 Ecosystem services

The unique ecosystems in the Pacific region provide many "ecosystem services" from which humans benefit. Ecosystem services are essentially sets of natural assets (e.g. soil, plants and animals, air and water) that have been transformed into things that we value. For example, insects such as bees interact and pollinate flowering plants which, in turn, bear fruit and seeds that provide food for animals and viable seeds to renew the cycle. The complex process of pollination is directly linked with insect life-cycles and plant flowering patterns, which are both strongly dependent on climate and seasonal weather variations.

Other examples of ecosystem services include:

- insect pest control
- maintenance and provision of genetic resources
- maintenance and regeneration of habitat
- provision of shade and shelter
- prevention of soil erosion
- maintenance of soil fertility and waste recycling
- regulation of river flows, groundwater levels, and water filtration.

Ecosystem services are little understood, extremely difficult to model but integrally important to the sustainability of root crop production in the Pacific. Climate change threatens to disturb the natural balance of Pacific ecosystems that will, in turn, impact the natural services they provide. To mitigate the impacts of climate change, the role of ecosystem services will need to be closely considered and must be the focus of targeted research.

(See Module 3 for more information on the role of ecosystem services in food security.)

module 2

AN OVERVIEW OF THE KEY PACIFIC FOOD SYSTEMS

2.0 KEY PACIFIC FARMING SYSTEMS

There are a variety of traditional and modern farming systems used in the South Pacific for crop and livestock production. While traditional farming systems (TFSs) still dominate agricultural production in most PICTs, they are being increasingly undermined by monoculture-based agriculture practices, urbanization, and lifestyle and dietary changes that are combining to make PIC communities more and more reliant on cash cropping and imported foods such as flour, rice and chicken meat.

Traditional farming systems can be defined as "*sets of interconnected customary practices of producing crops and animals for food, socio-cultural uses and export which conserve resources, protect the environment and are passed down from generation to generation*" (Tofinga in USP/IRETA, 2001: See TOOL 34). Traditional farming systems range from low-input shifting agricultural (swidden) systems, which can be found throughout the Pacific region, to high-input permanently cultivated systems. In contrast to modern, conventional farming systems, most TFSs are characterised by the integrated use of trees, mixed cropping, extended fallow periods and natural rainfed irrigation.

Many Pacific Island countries have embraced commercial crop and livestock production since the late 1970s with varying degrees of success and environmental impact. The "modernization" process, however, began much earlier and in parallel with colonization of the region by Great Britain, France, Germany and the USA. One of the legacies left by expatriate colonizers is the plantation system, which has become the core of modern agroforestry throughout the Pacific region. In some PICTs, large-scale deforestation has led to monocultural crop production solely aimed at earning foreign exchange. The transition to cash cropping has seen a strong shift away from traditional low-input, diversified agroforestry systems and has resulted in growing reliance on imported food products. (FAO, 2008; IRETA, 1988: See TOOLS 1 & 27.)

The central objective of the modernization of agriculture in the Pacific Islands, as elsewhere, has centred on raising agricultural productivity to levels which allow farmers to produce more than that required for subsistence only (Ali and Murray, USP/IRETA, 2001: See TOOL 34). The drive to increase productively has typically led to an intensification of cultivation on existing farmland, and the extension of cultivation onto previously unused and/or forested and marginal land in PICTs. Examples of intensified modern farming practices are evident throughout all PICTs and include coffee in Papua New Guinea (PNG), taro in Fiji, vanilla and kava in Tonga, and past surges of squash production in Tonga and Vanuatu, to name but a few.

While examples of large-scale commercial farming practices, characterized by the clear-felling of trees and intensive use of fertilizers, insecticide and herbicide, can be found in most PICTs, the majority of these "modern" farming operations are largely restricted to the Melanesian countries. Elsewhere, large-scale farming operations have often met with limited success or outright failure. The Tonga squash boom of the late 1990s provides one such example of the fragility of modern monocultural cropping systems within the Pacific Island context. The squash production boom in Tonga left many subsistence farmers broke and alienated from their lands as banks foreclosed on loans and confiscated land that was used as collateral.

2.1 TRADITIONAL CROPPING SYSTEMS

While most TFSs are largely variations of shifting agriculture, there are other types of TFSs that focus on modifying soil growth conditions. Hunter and Delp (USP/IRETA, 2001: See TOOL 34) argue that the most important of these alternative cropping systems focus on soil-water management practices that have been developed for taro cultivation. They refer to these cropping systems as *pond-field*, *raised-bed* and *atoll-pit* cultivation systems. Ali and Murray (USP/IRETA 2001: See TOOL 34) also describe different types of *terrace garden systems* that were once prevalent in Fiji but are no longer widely employed in the region.

In the Pacific, raised-bed agriculture continues to be used for the cultivation of mainly root crops and represents a highly productive form of cultivation. The system typically comprises the formation of raised beds of soil or decaying plant materials. Soil material is often sourced from surrounding ditches which in turn encourages drainage in swampy or low-lying areas. Such systems are used for the permanent cultivation of sweet potato in the highlands of Papua New Guinea (Ali & Murray, USP/IRETA, 2001: See TOOL 34).

In contrast, pond-field systems are created by surrounding small plots with raised banks that facilitate the controlled ponding of water within the plots. These systems are still used in Fiji for the production of taro varieties that tolerate saturated soil conditions. Pit cultivation of giant swamp taro (*Cyrtosperma Chamissonis*), which is an important food production system in some atoll countries, could be considered another variation of the pond-field systems. Pit cultivation systems involve the excavation of large pits down to the water table which are partly refilled with soil and decaying organic matter. In Kiribati, for example, swamp taro (Pulaka) is planted in 10m x 20m pits, 2-3 m deep, with the taro corm placed in "organic baskets" of Pandanus and *Cocos nucifera* and anchored in holes 60 cm below the water level (IPCC, 1997; Tofinga in USP/IRETA, 2001: See TOOLS 25 & 34).

Variations of this method are used elsewhere in the region, including the Cook Islands and Kiribati, where giant swamp taro is either grown in pure stands or in combination with Colocasia taro and even bananas.

2.2 AGROFORESTRY SYSTEMS

Agroforestry systems deliberately combine selected forestry and agricultural crops (predominantly root crops in the Pacific) to ensure short-term crop productivity and longer-term environmental sustainability (IRETA, 1988).

Tofinga (USP/IRETA, 2001) and PRAP (1999) outline several categories of "traditional" agroforestry systems that are used in the Pacific region. (See TOOLS 29 & 34.) These include non-permanent, permanent, tree intercropping and "backyard garden" agroforestry systems. For the purposes of this toolkit, a coarse division can be made between: (i) extensive low-input shifting agroforestry systems, typical in areas of low population density in Melanesia and parts of Polynesia, and (ii) intensive agroforestry systems that are characteristic of the smaller, more highly populated islands and atolls of Polynesia and Micronesia, and of urban areas throughout the Pacific (Thaman, 2008: See TOOL 32).

2.2.1 Non-permanent agroforestry systems

Non-permanent or shifting agricultural systems are utilized throughout the Pacific region but particularly on larger islands within Melanesia and Polynesia. In areas of low population density, shifting agroforestry systems involve the felling or ring-barking of unwanted upper- and mid-canopy tree species. The underbrush and groundcover is then usually cleared by fire. The clearing process is typically carried out on fallow land or secondary growth forest but in some areas virgin forest may be cleared. The preserved trees, usually slow-growth forest, fruit or nut trees, and trees of medicinal or other cultural importance, are often pruned or pollarded, but not killed, to open up garden areas to sunlight and to add additional organic material and nutrients to the soil (Thaman, 2008: See TOOL 32). Clearing the land in this fashion facilitates the planting of a variety of food trees and crop species. The types of crops grown vary significantly from country to country or even island to island, but usually include one or more varieties of yam or taro. After several rotations, lowered soil fertility necessitates the cultivated land to be laid fallow for a period of 10 to 15 years or more.

Example of a shifting agriculture agroforestry system in Melanesia

A typical shifting agroforestry cropping cycle in Tonga starts with the clearing of understory vegetation which is burned off. On virgin land, upper-canopy species may be thinned by burning or alternatively felled for firewood or construction timber. Yams are then often intercropped with plantains, giant taro or other crops. After yam harvesting, American taro, swamp taro or cassava are generally planted next in succession. Other crops such as sweet potatoes, bananas, peanuts and a wide range of other crops may be co-planted at any time during the sequence. If taro is planted, then cassava is often planted up to four or five times before the land is allowed to revert to fallow (Fisk *et al.* 1976). In recent years, kava (*Piper methysticum*) has been increasingly integrated into the cropping cycle at the expense of food crops.

2.2.2 Permanent agroforestry systems

Home garden and permanent agroforestry systems are found within urban areas throughout the Pacific and are prevalent in rural locations within smaller atoll countries and upon smaller islands within Micronesia and Polynesia. They are typically more highly modified than non-permanent agroforestry systems and may require a greater level of input to maintain soil fertility and adequate soil moisture conditions, particularly on atolls where the soils tend to be thin, poorly structured and lacking in many major micronutrients. The agroforestry system in atoll countries is traditionally developed around three principal crops: coconut, breadfruit and pandanas.

2.2.3 Modern agroforestry in the Pacific

The high international demand for copra in the early twentieth century saw widespread areas of coastal land in Pacific Island countries planted to coconuts. In some PICTs, these coastal plantations also were intercropped with cacao and lowland coffee. Some plantation planting was also carried out in higher inland areas, such as the Central Highlands of PNG, where many large coffee plantations were established. Coffee was often inter-planted with introduced leguminous shade trees such as *Leucaena* spp.

Another version of modern agroforestry in the region is the silvopastoral type, in which cattle and horses are grazed under coconuts or timber tree species. The grazing cattle not only provide a source of valuable protein and income to the farmer, they also serve the multiple purposes of weeding plantations, reducing fire risk and contributing organic manure and nutrients to the surrounding trees (IRETA, 1988: See TOOL 27).

Example of a permanent or garden agroforestry system in Kiribati

A home garden in Kiribati is likely to include breadfruit, dwarf coconuts, te bero (a variety of fig), pandanus and pawpaw along with other selected tree species for forage, food and fuel. The trees are typically spaced out among an understory of vegetable and root crops. In favourable conditions, crops such as bananas, kava, pineapple, nonu and hibiscus species and coffee may also be integrated into permanent agroforestry systems.

2.2.4 Agroforestry tree species

The tree species integrated into Pacific agroforestry systems vary widely but often include coconut palms, a wide range of banana and plantain cultivars, breadfruit, sago palm, nut trees, edible pandanus species, malay or mountain apple, oceanic litchi, Polynesian vi-apple, pommel, joint-fir, edible figs, dragon plum, red-bead tree, a number of palms, including the betelnut and *Pritchardia* and *Veitchia* spp., and other less common species. Also increasingly common are recently introduced fruit trees, such as mangoes, avocado, papaya, soursop and sweetsop, carambola (*Averrhoa carambola*), new bananas (*Musa* cultivars) and a range of citrus trees, including sweet and sour orange, mandarin, lemon and lime (PRAP, 1999; Thaman, 2008: See TOOLS 29 & 32).

2.2.5 Agroforestry crops

The dominant staple ground crops in most traditional shifting agricultural systems are yams (*Dioscorea* spp.) and *Colocasia* taro, although other ground and tree crops, particularly banana and plantain cultivars, are also planted. Giant taro (*Alocasia macrorrhiza*) is also an important supplementary staple in Samoa and Vava'u in northern Tonga. Sweet potato, cassava and *Xanthosoma* taro are also becoming increasingly important in some PICTs.

Other ground crops include sugar cane, hibiscus spinach, pumpkin, pineapple, maize, chili peppers, cabbages, beans and non-food species such as kava (*Piper methysticum*), tobacco and the important handicraft plants, paper mulberry (*Broussonetia papyrifera*) and a wide range of *Pandanus* cultivars (PRAP, 1999; Thaman, 2008: See TOOLS 29 & 32).

2.3 LIVESTOCK SYSTEMS

Livestock production has played a very important role in the socio-economic development of the Pacific Island countries but has met with mixed success in the region. For many smallholder farmers, livestock production remains an important source of both protein and income. While pigs and poultry are produced throughout the PICTs, commercial production and the farming of ruminant animals including cattle, sheep and goat are largely restricted to the larger Pacific Island countries including PNG, Fiji, Solomon Islands, New Caledonia, Samoa, Tonga and Vanuatu. Elsewhere in the Pacific, the production of pigs, chickens, cattle and sheep tends to carried out on a smaller scale for household consumption. In 2001, ruminant livestock numbers were estimated at 713 050 cattle (beef/dairy), 262 400 goats, 24 900 sheep and around 120 000 farmed and feral deer (Aregheore *et al*., 2001: See TOOL 22).

The majority of livestock in the Pacific are reared on unimproved, poorly managed pastures; fallow land; roadsides; crop residues; under coconut agroforestry systems; and often on a combination of these forage sources. Accordingly, ruminant livestock rely mostly on native and some introduced grasses along with herbaceous shrubs and tree legumes, other non-leguminous trees, various weeds species and crop residues for their forage supply and intake.

The poor quality of pastures (carrying capacities of only 0.5 cattle/ha are common) is one of the main constraints hindering large-scale commercial livestock operations in the region. While significant research has been directed towards improving the stocking capacity of tropical pastures and identifying alternative, locally produced feeds including crop residues and industrial by-products, the quality and productivity of ruminant livestock production systems remains highly variable throughout the region (Aregheore *et al*., 2001: See TOOL 22).

Monogastric livestock, including poultry and pigs, are ubiquitous throughout Pacific Island countries and form an extremely important source of protein for many Pacific Islanders. An increasing number of countries are interested in establishing or expanding their livestock production beyond the present level, in order to increase the availability of animal protein and to substitute for imported products. However, small livestock production is still dominated by smallholders and households. Pigs and poultry are often kept in pens but many are also left to wander and forage in both rural and urban settings, often at the expense of vegetable gardens and crops!

2.4 COMBATING THE IMPACTS OF CLIMATE CHANGE

This section provides some keys steps that PICT governments, communities and/or individuals may consider to reduce the present and pending impact of climate change on Pacific agricultural production. They range from high-level, wide-reaching policy steps aimed at PICT governments and community leaders, to smaller practical steps that may be undertaken by individual farmers at the village level.

2.4.1 Combating poor planning

While climate change adaptation efforts must largely focus on concrete, on-the-ground initiatives within villages and communities, efforts also must be be levelled at climate change “mainstreaming”. This refers to the process of ensuring that the impacts and causes of climate change, and the steps to combat climate change and reduce its impact on people and the environment are fully considered in all government policies and development initiatives. Climate change mainstreaming is designed to ensure that robust political, economic and cultural frameworks are in place to provide an effective and supportive environment to combat climate change. The following steps should be undertaken to help ensure that efforts to strengthen agricultural and food security in the region adequately address climate change.

- **Step 1** – Farmers and communities should call for and support the mainstreaming of climate change adaptation and mitigation efforts into agricultural sector plans and all relevant national, sub-national and village policies and practices. Central themes of this mainstreaming work should include the promotion of food security initiatives and the development of National Adaptation Programmes of Action (NAPAs) and climate change strategies for all PICTs.

- **Step 2** - Care should be taken to ensure that land-use and agricultural sector plans and policies are revised to ensure that they are flexible and responsive to the uncertainties of climate change. They must also closely consider gender roles and how climate change will impact village activities, such as the collection of fuelwood and water for cooking.

- **Step 3** - In a future that will see existing water resources come under increasing pressure from growing populations, changing rainfall patterns and saltwater intrusion, the effective management of water resources for domestic and industrial use, electricity generation, recreation and tourism opportunities, and crop irrigation must become a top priority for all PICTs. Governments and Pacific communities alike must promote water resource management practices that look to promote water conservation; improved crop irrigation practices; and the development of water capture and storage initiatives.

- **Step 4** - As sea levels rise and populations grow, land-use planning must become a top priority for PICTs. Along with water catchment areas and aquifer recharge zones, cropping land must be identified and protected against encroachment from poorly controlled urbanization and the relocation of people forced from low-lying land. In countries where adequate policies already exist, they must be implemented and relevant legislation enforced.

2.4.2 Combating information gaps

Much of the global climate change research conducted to date on crop production has focused on rice, sugarcane, maize, barley, wheat and millet. These crops feed much of the world's ballooning populations in Europe, Asia, Africa and the Americas. There has been comparatively little "Pacific specific" research conducted on the impacts of climate change on tropical root crop production, particularly within the context of climate change in PICTs. Here are some steps that could help ensure that we have up-to-date and best practice information available to farmers and decision-makers in the Pacific region.

- **Step 5 – PICTs need to call for and support climate change-focused scientific research that models the effects of climate change on Pacific agriculture and also seeks to identify practical village-level solutions to adapting to climate change. The research gaps are numerous but a few notable areas, listed below, requiring further attention.**
  - Build a better picture of changing regional rainfall patterns and climatic variability associated with climate change. Information gaps could be filled by installing more meteorological observation stations, particularly in rural areas, and training staff on the use of climate information for farmers.
  - Assess climate impact at local level, which will be essential to determine appropriate adaptation measures.
  - Identify alternative crop production systems, such as coconut fibre farming and hydroponics.
  - Continue to identify and develop local and exotic crop varieties that can tolerate Pacific climate extremes, including heat stress, drought, water-logging, saline soils, wind throw and pests.
  - Optimise planting times for integrated cropping systems and low-input crop production practices.
  - Develop sustainable irrigation and water capture systems to combat variable rainfall and drought.

- Match soils and land-use potential with suitable crop species.
- Identify and control invasive species that impact agricultural production such as weeds, disease and pests.
- Prepare storm water management and capture plans.

- **Step 6** - To ensure climate change-focused agricultural research is successful, it must strongly target Pacific farmers' needs and, where practicable, draw upon their skills and expertise at all stages of the research process.

- **Step 7** - A regional approach to the sharing of climate change adaptation initiatives and "lessons-learned" is critically important to build Pacific expertise that can be shared among neighbouring countries.

2.4.3 Combating sea-level rise

Many low-lying areas and flood plains will become increasingly impacted by rising sea levels, storm surges and flooding as the impacts of climate change take hold in the Pacific region. Effective land-use planning will be critical to help protect soil and water resources, and natural ecosystems against the impacts of climate change. As some agricultural land becomes inundated and/or contaminated from seawater incursion, other areas of land will need to be brought into production. Here are some steps aimed at protecting Pacific island natural resources.

- **Step 8** - In addition to supporting the development and implementation of effective land-use plans (see mainstreaming section), it is vital that farmers and communities move to identify and protect soil and water resources such as valuable cropping land, water catchments, ground water reserves and coastal vegetation. For example, highly fertile and elevated land may need to be earmarked and retained for future agricultural use, particularly in areas where existing agricultural land is low lying and/or prone to flooding.

- **Step 9 – In the Pacific context, seawalls do not provide an economically viable nor environmentally sustainable solution for preventing sea-level inundation of low-lying coastal land. Rather, they are suited to specific applications such as protecting high value infrastructure, including roads and buildings in zones impacted by active coastal erosion. Constructing a seawall to protect your agricultural land is likely to be costly, ineffective in the long-term, harmful to the environment and will probably transfer erosion or flooding problems to neighbouring farms or villages.**

- **Step 10 – While it is unrealistic to think that climate change-induced coastal erosion in PICTs can be totally prevented, it is important to reduce human activities that further contribute to coastal erosion processes. Activities such as the mining of corals and sand, the development of coastal infrastructure, and the deforestation and degradation of coastal forests, mangroves and wetlands must be closely regulated.**

2.4.4 Combating droughts

Without question, water is one of the region's most precious and sometimes most undervalued natural resources. As populations grow and climate change takes hold, potable water will become an increasingly valuable resource in many PICTs particularly within low-lying atoll countries.

Many PICTs will have to make vast improvements in existing water resource management practices and begin to capture and store rainfall for drinking and crop irrigation. Here are some steps designed to combat the impacts of reduced rainfall and drought that may become more widespread in a future Pacific region.

Figure 2.1: **Harvesting rainwater is one way you can improve your family's water security for crop irrigation, washing and drinking. On this building, each square metre of roofing iron can capture 1 litre of high quality water following just 1mm of rainfall! When you multiple roof area by the total amount of rainfall received, it may be possible to capture and store tens of thousands of litres of clean water each year.**

~ **Step 11** – PICT communities must look to develop and enforce effective water resource management strategies that focus on water conservation, recycling and water harvesting practices. For example, water used for laundry, washing and bathing can be recycled and used for flushing toilets and may also be suitable for sustaining crops during times of drought.

~ **Step 12** – The adoption of bucket irrigation and water harvesting from buildings for crop irrigation are likely to become increasingly important practices, particularly in atoll nations and drought prone areas.

~ **Step 13 –** Drought increases the risk of forest, crop and grass fires. PICT governments and communities need to address these risks by developing and implementing strategies to reduce the risk of fires. At the community level, evacuation plans should be implemented and forest fire breaks can be cleared to isolate adjacent forest blocks, crops and buildings from one another. Individuals can also reduce fire risk by clearing vegetation and trees away from houses, farm buildings and crops.

2.5.5 Combating storms and cyclones

Cyclones and severe storms already impose significant costs on PICTs. Unfortunately there is growing evidence to suggest that El Niño conditions may become more prevalent and increase the intensity of cyclones and storms by increasing wind speeds and mean and peak rainfall. Strong storms will accelerate coastal erosion, increase flooding and saltwater intrusion, and directly damage crops and agricultural infrastructure.

~ **Step 14 – Exposed coastal areas are likely to be increasingly impacted by storms, high winds and salt spray. Live-tree shelter belts may provide farmers with a cost-effective means of protecting inland crops and soils from coastal winds that can rob soils of valuable moisture, elevate salinity levels and directly damage crops with wind throw and salt burn.**

~ **Step 15 – Farmers can build resilience to cyclones and storms by diversifying agricultural crops and incorporating root crop species that may be less susceptible to high winds, heavy rainfall and water-logged soil conditions.**

~ **Step 16 – As new buildings are constructed and old buildings upgraded, care should be taken to ensure that they are climate-proofed against high winds and heavy rainfall, and located away from flood prone areas, vulnerable coastlines and large trees that may be susceptible to wind throw.**

(See TOOLS section for further sources of information on a climate change mitigation and adaptation measures.)

THE ROLE OF ECOSYSTEMS IN RESILIENT FOOD SYSTEMS IN THE PACIFIC

3.0 ECOSYSTEMS AND FOOD SECURITY

Ecosystems fulfil important functions that underpin food security in a number of ways. Based on the categories of ecosystem services specified within the Millennium Ecosystem Assessment (2005), it could be argued that the two most important are *provisioning services,* which means providing a supply of food that is sufficient to meet nutritional and dietary requirements, and *regulating* services, which means stabilizing this food production by regulating conditions, such as by acting as a "bioshield" to disperse energy from extreme events.

In the Pacific, the likely changes to the intensity and occurrence of extreme events expected under climate change has led to a disaster risk reduction approach within many national adaptation planning responses. The Millennium Ecosystem Assessment (2005) (See TOOL 39) produced clear evidence that in addition to supporting people's day-to-day livelihoods, ecosystems such as coral reefs, mangroves, wetlands and mountain forests are also important in mitigating the impact of natural hazards. Analysis of recent disasters, such as the December 2004 Indian Ocean tsunami and the hurricanes that struck North and Central America in September and October 2005, demonstrates the importance of habitat protection and natural resource management in decreasing our vulnerability to extreme events. Unfortunately, these factors are often not considered in development planning and disaster relief operations. This leads to increased vulnerability to future hazards and loss of biodiversity.

This chapter outlines the relationship among the food security issues, ecosystem services and climate change impacts in Pacific Island countries. One of the challenges in ecosystem-based adaptation is that the interaction among these ecosystem service and climate variables is very complex, and providing quantitative estimates of their significance is nearly impossible. According to UNEP (2009), the key ecosystem service variables are not currently accounted for in most models and scenarios of food production. (See TOOL 38.) Hence, rather than providing quantitative tools to support decision-making, this chapter describes contexts in which a selection of the ecosystem-based adaptation options may be part of the solution to food insecurity.

Across the Pacific Island countries, the main ecosystem types that underpin the sustained productivity of some of the key food resources relate to the functions of terrestrial, marine and coastal ecosystems. While some of the key ecosystem service and adaptation relationships are described in this chapter, the list is not comprehensive and other approaches may be applicable in some Pacific contexts, such as those which link forests and wetlands with water regulation, the role of marine and terrestrial protected areas and pollination/insect services.

3.1 TERRESTRIAL SYSTEMS

3.1.1 Vegetation complexity and landslides

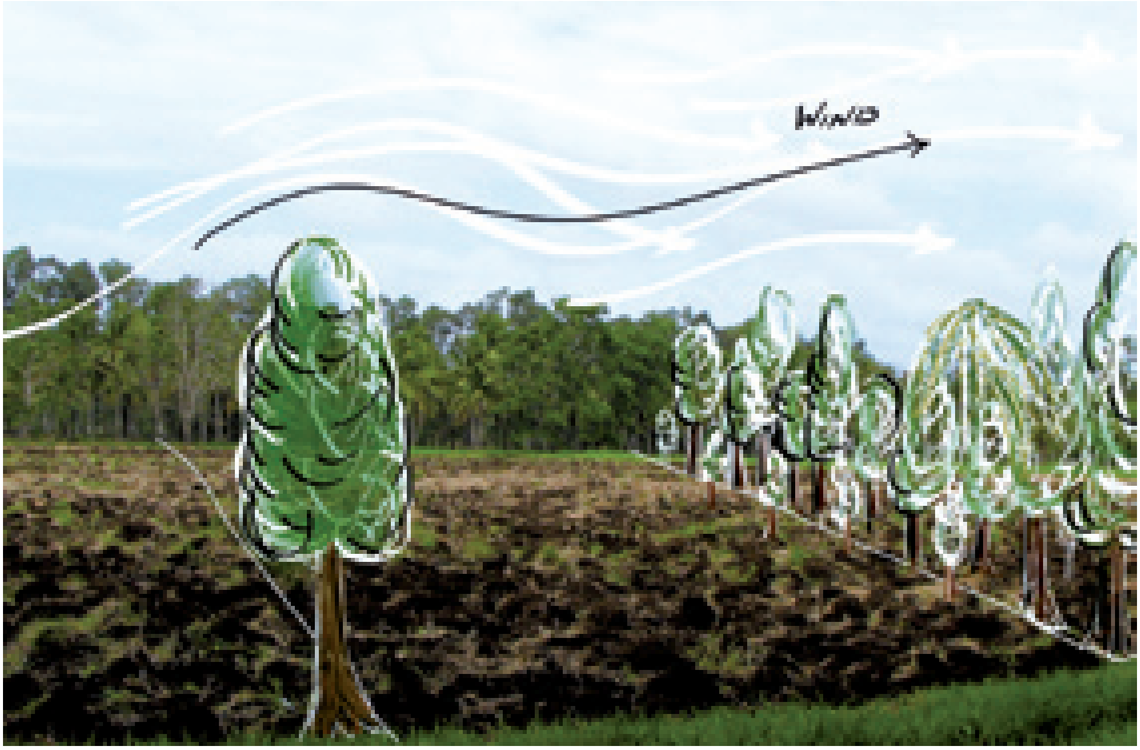
One of the most practical ecosystem-based adaptation applications that can be considered in the Pacific is based on the relationship between vegetation and landslides. Increase in populations and other development pressures in mountainous environments of PICTs such as Fiji and PNG see agriculture moving to more marginal areas including hill slopes. These areas are already vulnerable to landslides, and the combination of land clearing and the potential for more intense rainfall events in future climate regimes translates to an even higher level of landslide risk. There is an increasing body of evidence that supports this. For example, Philpott *et al.* (2008) found that at the farm scale, increasing management intensity (reducing vegetation complexity) correlated with an increased proportion of farm area and roadsides affected by landslides. (See TOOL 37.)

This has direct application within agricultural practices in that monocropping operations with typically low complexity will translate to a higher risk of landslide. The policy and management implications of this are that more diverse agricultural regimes should be applied to reduce risk in areas of agricultural production that are vulnerable to increases in severe weather events. In Pacific landscapes, practical steps could include the integration of native and agroforestry operations to reduce the risk of landslides in agricultural areas where increased high intensity rainfall events are expected.

3.1.2 Shelter belts

Trees play an important role protecting crops from the ravages of storms, strong winds and salt spray. Live-tree shelter belts can provide farmers with a cost-effective means of protecting inland crops and soils from coastal winds that can rob soils of valuable moisture, elevate salinity levels and directly damage crops with wind throw and salt burn. Accordingly, trees play an integral role in traditional agricultural systems in the Pacific, providing shelter along with firewood, building timber, tree crops (nuts and fruits), and handicraft materials. (See TOOL 29.)

Figure 3.1: **Trees and carefully placed shelter belts add value to a farm. They can help reduce wind damage to crops; capture salt-spray; retain soil moisture; provide shelter to livestock; and produce fruits, nuts, firewood and building timber. So please think twice before clearing your land, as trees are an important resource that can both combat the impacts of climate change and help trap excess carbon dioxide in the atmosphere!**



3.2 COASTAL AND MARINE SYSTEMS

The coastal and marine systems offer both provisioning and regulating services – provisioning services largely through habitats, and regulation services by acting as ecological buffers from the destructive forces of extreme weather events. Both coral reefs and mangroves contribute significantly to the economies of small island developing states and, as such, their maintenance is important for livelihoods and food security throughout the Pacific (Wells *et al*., 2006: See TOOL 70). From a food security and livelihoods perspective, both coral reefs and mangroves support many types of fisheries – artisanal, commercial and recreational for numerous types of fish, lobsters, crabs, molluscs and many other species. Both of these ecosystems are prominent features of Pacific Island landscapes and offer significant opportunity to reduce the impact of climate change on food security across the Pacific.

While upland and floodplain forest-based adaptation solutions have limited application across the Pacific, adaptation options that take advantage of the ecosystem services associated with coastal and marine ecosystems have much broader scope for application. However, relative to the options available to terrestrial and coastal production systems, there is less that can be done to buffer the climate change impacts on marine systems. As a consequence, the ecosystem-based adaptation (EbA) options that are most likely to add resilience to the ecosystem services are those that remove other anthropogenic stressors, such as pollution, sedimentation, unsustainable fishing practices and poor coastal development planning.

While both coral reefs and mangroves can protect food security by reducing intensity of climate-related events such as storm surges before they reach areas of human settlement, the ecosystems themselves are usually damaged in such events. Thus their buffering capacity is a balance of both their resilience and vulnerability (Wells *et al*., 2006: See TOOL 70). In order to optimize the “bounce-back” of these ecosystems from such events, their resilience can be strengthened by minimizing anthropogenic stressors.

As the specific services and management responses for mangroves and coral reefs are quite different, their potential as EbA solutions is described separately below. Additionally, the role of seagrasses in adaptation is also explored.

3.2.1 The role of mangroves

As discussed above, mangroves can play a critical role in protecting communities from increasing severe weather events, such as cyclones, that may become more intense with climate change. Not only can mangroves help save lives, they can also protect food production systems that lie further inland, along with the food production services that mangroves promote directly, as related to fisheries. Further study has shown that the buffering capacity of mangroves is impacted by both the quality of the mangrove forest, and its size or the extent of its re-growth if it has been cleared (Wells *et al*., 2006: See TOOL 70). Mangroves are critically important as breeding and nursery areas for many important species of fish and prawn and represent an important source of timber. For example, in Matang, West Malaysia, 40 000 ha of managed mangrove forest yields US$10 million in timber and charcoal and over US$100 million in fish and prawns every year (Talbot and Wilkinson 2001: See TOOL 19). In Southern Thailand, mangrove forests provide an estimated US$3 679 of coastline protection and stabilization service per hectare (Suthawan and Barbier 2001: See TOOL 79).

However, due to a lack of long-term sustainable management, mangrove ecosystems are threatened largely by conversion to aquaculture; industrial, residential and tourism development; timber extraction; and use of wood for fuel and charcoal production (Wells *et al*., 2006: See TOOL 70). Gilman *et al*. (2007: See TOOL 75) considers Pacific Island mangroves to be at high risk of substantial reduction.

An important characteristic of mangrove systems and their relationship with climate change relates to their capacities to accommodate sea level rise. In the absence of barriers such as those posed by coastal development and aquaculture ponds, mangrove systems have the capacity to migrate landward. Gilman (2007: See TOOL 75) notes that coastal planning can adapt to facilitate mangrove migration with sea-level rise "*through the management of activities within the catchment that affect long-term trends in the mangrove sediment elevation, better management of other stressors on mangroves, [and] rehabilitation of degraded mangrove areas…*".

Natural recovery from disturbances and removal of stressors is often sufficient to increase the resilience and health of ecosystems (Wells *et al*., 2006: See TOOL 70). However, active rehabilitation or restoration should be considered in areas of high risk of extreme climate events. In such cases, the emphasis of such programmes should be on the restoration of ecosystem function in the local hydrological context, rather than "getting seedlings in the ground". While such programmes are more complex to design and implement, this is preferable given the large failure rate in restoration programmes and the additional livelihood benefits of a more rigorous approach. The 5-step programme for the ecological restoration of mangroves outlined by the Mangrove Action Project provides guidance on avoiding the pitfalls in mangrove restoration programmes, including species selection, hydrological considerations and rehabilitation design. (See TOOLS 75-79 for more information on mangroves.)

3.2.2 The role of coral reefs

In addition to being one of the most biologically diverse ecosystems on earth, coral reefs play an important role in food security in the Pacific from both a livelihoods perspective and a food production or availability perspective. The reef fisheries of Southeast Asia, for example, generate approximately US$2.4 billion/year (Wells *et al*., 2006: See TOOL 70). Economic benefits derived from tourism and fisheries globally result in US$30 billion/year, and 25 percent of all marine species rely on coral reefs for critical habitat (Buddemeier *et al*., 2004: See TOOL 67)[4]. Coral reefs support both commercial fisheries and aquarium fish. In other words, coral reefs play a critical

4 The total annual economic value of reefs has been estimated at between US$100 000 and US$600 000 per km^2 and the value of mangroves at more than US$900 000 per km^2 (see TOOL 67).

role in ensuring food security. They provide livelihoods that enable people to afford to purchase food plus they directly support the fish that represent a critical source of protein, without which many could potentially face malnutrition.

Coral reefs also play an important role in protecting the coastline and serving in a buffering capacity as breakwaters. The role of this service varies, depending upon the activity it is protecting along the coast. For example, reefs in Indonesia have been valued at US$829/km, based on the value of agricultural production that would be lost if there were no protection, at US$50 000/km in areas of high population density, and at US$1 million/km in areas of tourism which incorporates the associated cost of maintaining the sandy beaches (Wells *et al*., 2006: See TOOL 70).

In the case of coral reefs, these ecosystems are especially sensitive to changes caused by climate change. They already are being impacted by increases in ocean temperature, which cause coral bleaching episodes, and by changes in ocean chemistry resulting from increased amounts of CO_2 dissolved in the ocean due to fossil fuel combustion (Buddemeier *et al*., 2004: See TOOL 67). As a result of these global stressors, coral reef systems are less resilient and more susceptible to local stressors, including disease, overfishing, use of destructive fishing methods, and pollution and sedimentation from humans (Wells *et al*., 2006: See TOOL 70).

In order to increase the resilience of the coral reefs and ultimately minimize and buffer against the negative effects of global climate change, efforts should be made to protect coral reefs from non-climate stressors (Buddemeier *et al*., 2004: See TOOL 67). This is relevant for food security, because it will ultimately reduce the risk to communities from loss of functioning coral reef systems. One method used for the identification of hot spots in reef vulnerability is the concept of degree heat weeks (DHW), which is the number of weeks in which the sea surface temperature of an area exceeds its average thermal maximum by 1-2° C. DHW has become a key operational metric for reef monitoring and management, and assessing the risk of coral bleaching. National Oceanic and Atmospheric Administration (NOAA) has combined this temperature threshold concept with a duration factor to develop the DHW alert system that uses satellite imagery of sea surface temperature to detect potential areas of coral bleaching (See TOOL 67).

Along with reducing pollutant loads, another ecosystem-based approach to reducing the local stressors on coral reefs, and thereby improving the bounce-back from bleaching and storm-event damage, is to design and implement locally managed marine areas (LMMAs). Such protected areas would help ensure the minimization of local stressors, promote local governance and locally derived benefits from eco-tourism and healthy fish populations, and require the establishment of a monitoring and evaluation programme in order to monitor the status of the coral reefs. (See TOOLS 66-74 for more information on coral reefs.)

3.2.3 The role of seagrasses

While there is less awareness of the ecological functions associated with seagrasses than with coral reefs and mangroves, their functions are no less important and have been estimated to be worth US$1.9 trillion in the form of nutrient cycling (Waycott, 2009: See TOOL 80). The other relevant ecosystem services provided by seagrasses and seagrass meadows that are relevant to food production include the provision of food for coastal food webs, provision of oxygen to waters and sediments, prevention of sediment resuspension, wave attenuation and shoreline protection (Duarte, 2002: See TOOL 81).

While there is reasonable understanding of the rate of decline of seagrasses in some areas, there is a large data gap that exists in the Indo-Pacific Region (Waycott, 2009: See TOOL 80). Globally, excess nutrients and sediments are the main current causes of seagrass decline (Orth, 2006: See TOOL 82). Subsequent loss of seagrasses causes sediment resuspension, which negatively affects fish populations. Similar to mangroves, seagrasses migrate landward with sea level rise, have extremely high light requirements, and barriers to such migration will cause dieback (Orth, 2006: See TOOL 82).

In the Pacific, the use of pesticides is generally a less significant problem relative to other regions due to the prevalence of shifting cultivation as a soil conditioner rather than a dependency on fertilizer, but increased turbidity associated with increased likelihood of storm events and the availability of sediment from shifting cultivation means that sediment management in coastal areas may become a significant focus of EbA efforts.

In some areas of the Pacific, there are high degrees of dependency on seagrasses for direct and indirect production of coastal resources (Unsworth and Cullen 2010: See TOOL 83). The loss of this habitat can therefore result in negative consequences for food security. Due to the importance of seagrasses for livelihood and food security in the Pacific, especially as certain organisms depend on this habitat throughout certain phases of their lives, an ecosystem-based approach would entail that seagrass beds be managed at scale, and interconnected to other important ecosystems to restore and maintain ecosystem health for the provision of the needed ecosystem services across the land and seascape. (See TOOLS 80-84 for more information on seagrasses.)

3.3 COMBATING LOSS OF BIODIVERSITY AND FARMING SYSTEMS DECLINE

Traditional farming systems in the Pacific have endured and sustained Pacific populations through centuries of droughts, cyclones and other natural disasters. Indigenous farming knowledge has been dutifully passed down through countless generations and is based upon low-input, sustainable practices that focus on crop integration and natural methods of controlling weeds, pests and maintaining soil fertility.

Many traditional farming practices provide a basis to address modern climate change by improving food security in times of climatic variability. They can be drawn upon to enhance food security and to prevent the proliferation of energy-intensive cropping practices, many of which are unsustainable in PICTs and contribute significantly to global warming and environmental degradation. Here are some adaptation steps that are designed to promote crop diversification and maintain ecosystem services, while minimizing adverse environmental impacts.

- **Step 17 –** PICT governments and communities should develop and promote the use of farming systems more suited to changing environmental conditions. Traditional agroforestry and "modern" organic farming systems focus on crop diversification, crop integration and low-input production practices. These farming systems take a balanced approach to crop production and have been shown to provide greater food security during variable and/or adverse climatic conditions. They also tend to conserve soil and water resources and the many ecosystem services that are critical to sustaining agricultural production.

- **Step 18 –** The past push for monocultural, export-driven cropping enterprises that essentially "*put all of a farmers eggs in one basket*" must be reassessed within the context of pending climate change and increased climate variability. By design, monocropping initiatives tend to be high-input, involving large applications of fertilizers, pesticides and herbicides. They also lack crop diversity and, accordingly, run a higher risk of economic failure during market downturns and extreme weather events. Furthermore, they may offer precious little in the way of direct food security to farmers and their families.

- **Step 19 –** Farmers should be encouraged to draw upon those traditional and modern farming practices that focus on the sustainable management of soil fertility, pests and diseases. The use of tried and proven low-input practices such as integrated pest management, increasing fallow periods, companion planting and intercropping can all help sustain soil fertility levels and other ecosystem services. The adoption of sustainable farming practices is ultimately likely to reduce the vulnerability of root crop systems and the wider environment to the impacts of climate change.

- **Step 20 –** Sustainable farming practices that focus on building and maintaining soil humus (organic matter content) such as green mulching and manuring provide an important means of combating drought, nutrient leaching and soil erosion. These practices also contribute to capturing atmosphere carbon dioxide and help reduce climate change.

~ **Step 21 -** The integrated use of trees in agroforestry production systems provides opportunities to expand livelihoods by utilizing planted trees for construction and handicraft materials, firewood and alternative sources of food. When used for live fencing, shelter belts and the stabilization of steep terrain, trees are an effective trap for carbon dioxide and also provide a cost-effective means of buffering against heavy rainfall, sun, wind and salt spray.

3.3.1 Combating pests and diseases

Predicting and controlling the proliferation of new and/or existing pests and diseases in a future Pacific is without doubt one of the largest and most poorly understood challenges facing PICTs. The following are some steps that can be implemented to help reduce the risk and impacts of pests and diseases.

~ **Step 22 –** Awareness programmes to ensure that farmers and relevant stakeholders are aware of what "invasive species" are and how they can adversely impact agriculture and root crop production in Pacific Islands are critically important. Stakeholders also should be made aware of how individuals and communities can play a role in preventing the introduction of new pest species and the proliferation of existing pests and diseases.

~ **Step 23 –** When it comes to invasive species, prevention is the best solution. Pacific communities must support authorities to implement quarantine measures that help ensure that new pests and diseases are not introduced from the illegal importation of plants and plant products, root cuttings, seeds, soil materials or fruits.

~ Step 24 – Where invasive pests and diseases are already present in a country, communities and farmers can play an important role in helping eradicate and/or contain pests. This may involve helping physically eradicate pests and weeds; adhering to national quarantine restrictions; and reporting new outbreaks of invasive species and diseases to agricultural authorities.

- **Step 25 –** It is vital that communities do not take biological eradication efforts into their own hands. Poorly planned biocontrol, such as introducing organisms, insects or animals (bio-agents) that attack a wide range of prey or hosts, has caused enormous problems on some islands. The ill-advised introduction of the cane toad (*Bufo marinus*) into Fiji and elsewhere to combat the cane beetle is an example of biocontrol gone wrong.

- **Step 26 –** While it will be impossible to stop some pests and diseases from establishing and flourishing in a warmer Pacific climate, farmers can help build resilience to Pacific farming systems by utilizing sustainable farming practices that focus on diversity and nurturing ecosystem services. Such an approach will help ensure that farmers are less exposed to the risk posed by invasive species.

- **Step 27 –** Mangroves and coastal forests play multiple roles in combating climate change and fostering food security. They provide habitats for birds, fish, crabs and other marine species and also provide a vitally important buffer between marine and terrestrial environments. As well as helping to protect land resources against the ravages of cyclones, storm surges and rising sea levels, they also simultaneously protect reefs and inshore fisheries from drainage waters that carry damaging silts and pollutants such as pesticides and fertilizers. Governments and communities must work closely together to secure and protect these vulnerable coastal ecosystems.

(See TOOLS section for further sources of information on a climate change mitigation and adaptation measures.)

Mangroves and coastal forests help protect inland crops from storm surges and damaging salt spray. They also help protect fisheries and coral reefs from the damaging effects of silts and pollutants. To help build resilience to climate change, we need to protect existing coastal forests and help to reestablish mangroves and coastal vegetation where they have been removed. Photo above shows mangrove deforestation; photo below shows mangrove planting. (Tongatapu, 2009)

PACIFIC ROOT CROPS

4.0 ROOT CROPS IN THE PACIFIC

Tropical root crops are grown widely throughout tropical and subtropical regions around the world and are a staple food for over 400 million people. Despite a growing reliance on imported flour and rice products in the Pacific, root crops such as taro *(Colocasia esculenta)*, giant swamp taro *(Cyrtosperma chamissonis)*, giant taro *(Alocasia macrorhhiza)*, tannia *(Xanthosoma sagittifolium)*, cassava *(Manihot esculenta)*, sweet potato *(Ipomoea batatas)* and yams *(Dioscorea* spp.*)* remain critically important components of many Pacific Island diets, particularly for the large rural populations that still prevail in many PICTs (Table 4.1).

Colocasia taro, one of the most common and popular root crops in the region, has become a mainstay of many Pacific Island cultures. Considered a prestige crop, it is the crop of choice for traditional feasts, gifts and fulfilling social obligations in many PICTs. Though less widely eaten, yams, giant taro and giant swamp taro are also culturally and nutritionally important in some PICTs and have played an important role in the region's food security. Tannia, cassava and sweet potato are relatively newcomers to the Pacific region but have rapidly gained traction among some farmers on account of their comparative ease of establishment and cultivation, and resilience to pests, disease and drought.

Generations of accumulated traditional knowledge relating to seasonal variations in rainfall, temperature, winds and pollination, and their influence on crop planting and harvesting times now lie in jeopardy given the unparalleled speed of environmental change impacting the region. Left unchecked, climate change will seriously erode food security and agricultural livelihoods in all Pacific Island countries. To make substantial reduction in the pending impacts of climate change on agricultural productivity in the region, climate change must be tackled head on with a calculated and planned approach that draws on both modern and indigenous agricultural production practices. Arguably the greatest challenge lies in synthesising and transferring this knowledge to the many thousands of Pacific Islanders growing crops for the dinner plate and market place alike. (See TOOLS 1-46 for further information.)

Table 4.1: Root crop production, populations, total and arable land areas for FAO member states in the Pacific region

PACIFIC COUNTRY	TARO (tonnes/year)	CASSAVA * (tonnes/year)	TOTAL POPULATION (year)	RURAL POPULATION	LAND AREA (km2)	ARABLE LAND
Cook Islands		1 500	19 569 (06)	30%	236	12.7%
FSM			107 008 (00)	78%	702	3.7%
Fiji	74 009	55 773	827 900 (07)	49%	18 272	9.2%
Kiribati	2 200	50	92 533 (06)	54%	726	2.5%
Marshalls			50 840 (99)	33%	181	10.8%
Nauru			8 800 (07)	0%	21	-
Niue	3 300		1 625 (06)	-	260	11.6%
Palau			1 990 (05)	23%	459	2.2%
PNG	285 000	145 000	6 600 000 (09)	85%	462 000	0.5%
Samoa	18 634		180 741 (06)	78%	2 831	8.8%
Solomons	44 000	25 000	533 672 (06)	84%	28 896	0.6%
Tonga	3 800	97 000	101 134 (06)	57%	747	19.9%
Tuvalu			12 177 (08)	58%	26	-
Vanuatu	Unreported		217 000 (05)	76%	12 189	1.7%

**Estimated production source* = 2008 FAOSTAT data: www.faostat.fao.org

4.0.1 Root crop nutrition

Root crops are widely available in all PICTs and form one of the main sources of energy and nutrients for Pacific Islanders. For example, tubers represent almost 40 percent and 50 percent of the energy intake in Tonga and the Solomon Islands, of which taro is a vital component. The taro tuber (corm) is an excellent source of both energy and fibre and, when eaten regularly, provides a good source of calcium and iron. Sweet potatoes and yams are also good sources of energy, which the body needs to stay active. The yellow and orange varieties of the sweet potato root contain a high amount of Vitamin A and all varieties contain appreciable quantities of Vitamin C. Yams provide significant quantities of vitamin B1, vitamin C and dietary iron and niacin.

Some Pacific root crops such as sweet potato, taro and cassava have leaves that are also edible and nutritious. Taro leaves, for example, are an excellent source of protein,dietary fibre and a wide range of vitamins and minerals including carotene, potassium, calcium, phosphorous, iron, riboflavin, thiamine, niacin, vitamin A and vitamin C. (See TOOLS 33 & 44 for further information on nutrition.)

4.0.2 Pacific trade

While Pacific root crops are grown largely for domestic consumption in gardens and smallholdings, some international trade of root crops is carried out with Australian and New Zealand and, to a lesser extent, North America. While there is good scope to expand these and other international trade markets, efforts are also required to promote and establish intraregional trade of root crops between neighbouring Pacific Islands. Such trade has the potential to improve regional food security and to create livelihood opportunities within Pacific Island agricultural sectors.

4.0.3 Storage and preservation

Most types of root crops can be “field stored”, meaning left in the ground to grow, for varying lengths of time until they are needed for eating. The time varies from a few months to many years in the case of *Cytosperma* taro. In fact, given that some root crops, such as Colocasia taro, can perish quite quickly following harvesting, field storage is often the best solution for keeping root crops fresh.

When field storage is not practicable, there are some traditional methods of preservation that can be used to extend the shelf life of root crops. One such method involves storing the tubers underground in purpose-built pits lined with coconut husks or banana leaves that are then covered with soil. The tubers may be kept for up 2 to 3 months in this fashion.

It is also possible to bake the tubers in a hot earth oven until an external crust is formed. The tubers can then be stored for up to a week or more before eating. Or, they can be preserved by parboiling the root, slicing it thinly and then sun-drying the tuber slices. Taro root prepared in this fashion will keep up to several months when stored in a tightly sealed jar, tin or plastic bag.

In Hawaii and Tahiti, taro is also stored as poi – a food that is commonly consumed during traditional feasts. Poi is made from Colocasia taro that has been steamed in an earth oven, peeled and then pounded on a flat stone or a special wooden bowl (*kumete*) to form a paste-like texture. During the process of pounding, a small amount of water is added to achieve the best consistency of the mixture to form the poi. It can then be eaten fresh, stored overnight to mature (ferment) for flavour, or stored for several weeks before being consumed.

The spread of freezers through the Pacific region has obviously provided a modern method of preserving root crops for long-term storage. Peeling and freezing of root crops can provide convenient storage for several months and is increasingly used by Pacific agricultural exporters to bypass stringent quarantine requirements imposed by developed trading partners. (See TOOL 45 for further information on traditional food storage techniques.)

4.0.4 Growing conditions

Because there are a variety of tropical root crops grown in the Pacific, there are essentially crops suited to almost every climate and growing condition encountered across the region. Even in locations where the soils are sandy, shallow and nutrient deficient, as is the case on many low-lying atolls, farmers improve soil growth conditions through the addition of organic matter and traditional fertilizers.

The variety of soil and rainfall requirements among the different root crops gives farmers the opportunity to mix-and-match different crops to different growing conditions. Astute farmers are also able to hedge their bets against variable rainfall by planting crops with differing soil moisture requirements. For example, cassava, tannia and sweet potato can be grown in semi-arid regions and are considered more drought tolerant than yam and taro species. In contrast, most varieties of taro are best adapted to higher rainfall areas, and some species actually thrive within saturated soil conditions and even within brackish waters containing 25-50 percent seawater.

Such conditions would quickly kill most types of root and vegetable crops. Table 4.2 provides an overview of the growth requirements for the major root crops cultivated in the Pacific region.

4.1 ADAPTATION STEPS FOR ROOT CROPS

In addition to many of the adaptation steps outlined in Modules 2 and 3, it is also important that farmers do not "*store all their eggs in one basket*". Climate change is likely to be accompanied by increased climate variability that will see increased frequency and/or intensity of extreme weather events including drought and flooding. By diversifying root crops and using drought and water tolerant varieties, farmers can reduce the risk of crop failure and build resilience into their farming practices. The following three adaptation steps specify root crops but could be applied equally to other agricultural crops.

~ **Step 28 - Growing multiple crops and diversifying crop mixes – to include drought-resistant varieties of cassava, tannia and taro – provides a useful means of helping maintain food security during dry spells and periods of mild drought. It also protects farmers against market fluctuations that may see the demand for some crops plummet during market surpluses.**

~ **Step 29 - Awareness among stakeholders of the probable impacts of climate change on agriculture and root crops is required at all levels. Farmers and relevant stakeholders should be made aware of the adaptive steps available to maintain and enhance agricultural production food security in the Pacific region.**

~ **Step 30 - Monitoring and evaluation systems to determine the success of agricultural adaptation strategies for root crops are critically important so that farmers can learn from their mistakes and successes and share this vitally important information.**

Table 4.2: **Description and growth requirements for the major root crops cultivated in the Pacific region (Primary Sources:** See TOOLS 29 & 30.**)**

ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
TARO *(Colocasia esculenta)* Known as: ~ *dalo* in Fiji, ~ *talo* in Samoa and Tonga, ~ *te taororo* in Kiribati, ~ *taro tru* in PNG, ~ *aelan taro* in Vanuatu.	**Description:** Taro is a perrenial herb that has heart-shaped leaves and grows 1-2 metres high. It is one of the most widespread root crops of the humid tropics. Its corm may be harvested 8 to 12 months after planting. The taro corm has limited – approximately two weeks – storage life post harvest. While there are eight recognized variants of common taro, only two are usually cultivated. Most of the taro grown in the Pacific is *Colocasia esculenta* (L.) Schott var. esculenta (also known as "dasheen" taro) which has a large central corm. *Colocasia esculenta* (L.) Schott var. antiquorum is often preferred in places where taro is grown primarily for leaves because it has a central corm with several relatively large "cormels" surrounding it. Colocasia taro is susceptible to some pests and diseases including taro leaf blight, plant leaf hoppers, caterpillars and mites. **Crop requirements:** Taro generally grows best in a wet, humid environment. Most varieties do not tolerate drought. It is typically grown in "wetland" conditions in upland areas with rainfall over 2 000mm/year but can tolerate lower rainfall if it is well distributed throughout the growing season. It responds well to N, P & K applications and is often the first crop grown in rotation following bush clearing. It is sometimes grown as a monocrop but is also widely planted in multiple cropping systems with other root crops including bananas, plantains and tree crops. It is not tolerant to salinity and, while shading may improve establishment, production is higher when exposed to direct sunlight in later stages of growth. It can be grown in both light (sandy) or heavy (clay) soils but prefers slightly acidic growing conditions (pH 5.5-6.5) and does not compete well with weeds during establishment.

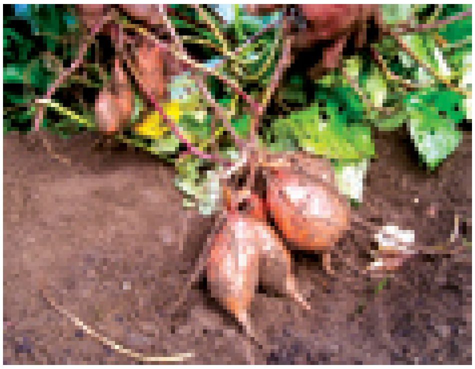
ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
GIANT SWAMP TARO *(Cyrtosperma Chamissonis)* Known as ~ *puraka* in Cook Islands, ~ *te babai* in Kiribati, ~ *pula'a* in Samoa, ~ *via kan* in Fiji, ~ *pulaka* in Tokelau, Tuvalu, ~ *simiden* in Chuuk, ~ *swam taro* in PNG, ~ *navia* in Vanuatu.	**Description:** Giant swamp taro is a "lowland" taro species and the largest of the taro family. It may reach heights of 4-5 metres, with leaves and roots much larger than Colocasia taro. It is one of the few subsistence crops that grows well on atolls and within swampy areas of other islands, and its corm can reach weights of 80 kg or more! It may be field stored in the ground for very long periods – up to 30 years or more – and accordingly has traditionally been an important emergency crop in times of natural disaster and food scarcity. It is relatively resistant to disease and pests but is susceptible to taro beetle. It can take several years to mature but is commonly left for 15 years or more before harvest. **Crop requirements:** As indicated by its name, giant swamp taro has adapted to growth within fresh water and coastal swamps. It is also commonly grown in purpose-built swamp pits in low-lying coral atolls. In the case of constructed pits various kinds of organic matter and fertilizer are usually added to the pit to improve the soil fertility, physical properties and waterholding capacity. Giant swamp taro is not suitable for growing in upland or rainfed conditions. It exhibits some shade tolerance and is considered mildly tolerant of saline growing conditions compared to other taro species, and can be grown in mildly brackish water.

ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
GIANT TARO *(Alocasia macrorrhiza)* Known as: ~ *ta'amu* in Samoa, Tuvalu, ~ *kape* in Cook Islands, Tonga, ~ *te kabe* in Kiribati, ~ *paragum* in PNG, ~ *fila* in Solomon Islands, ~ *via* in Fiji, ~ *pia* in Vanuatu.	**Description:** Giant taro is a hardy plant with a thick starchy edible stem. It is predominantly found in Tonga and Samoa and is not as popular as other types of root crops. The corm may grow up to 30 cm or more in diameter and up to 2 metres in length. It is increasingly used as fodder for animals in some PICTs but will be eaten when other foods are in short supply. It is a hardy crop that is resistant to insect and pests but often sought out by foraging pigs. It can be harvested after 12 to 18 months but can be left to grow in place for several years, making it an important crop in times of food scarcity. **Crop requirements:** This is an upland crop that grows best in well-drained soils with well-distributed rainfall of more than 2 000 mm/year. The crop does not tolerate poor drainage but may be relatively resistant to water stress and shade as it is often grown in stony or rocky soils and within multiple cropping systems with taller crops. It is not considered salt tolerant but is suited to both light (sandy) soils or heavier soils found on volcanic islands.

ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
TANNIA *(Xanthosoma sagittifolium)* Known as: ~ *dryland taro* or *talo futuna* in Tonga, ~ *tarua* in Cook Islands, ~ *talo palagi* in Samoa, ~ *taro Fiji* in Vanuatu, ~ *singapo* or *taro kongkong* in PNG, ~ *te tannia* in Kiribati.	**Description:** This crop is considered easy to grow and produces a relatively high yield within 6 to 12 months after planting. It is often grown in Melanesia, where both its pointed leaves and roots are eaten, but is not particularly suited to sandy, infertile atoll soils. Tannia was brought to the Pacific about 100 years ago and is resistant to many of the pests and diseases that affect Colocasia taro. It is also much more tolerant of drought than common taro with the added advantage that, once harvested, the root may be stored in a cool, dry place for several months. **Crop requirements:** This crop is considered an upland taro species and grows best in areas receiving between 1 500 to 2 000 mm of rainfall per year, although it can be grown in areas with rainfall as low as 1 000 mm/year. The plant roots within 15-20 cm of the soil surface and requires well-drained and relatively fertile growing conditions. It is not well suited to planting on sandy, nutrient-deficient atoll soils but can be grown where these soils have been amended with organic materials. It is not considered salt tolerant.

ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
CASSAVA *(Manihot esculenta)* Known as: ~ *maniota* in Cook Islands, ~ *tapioca* or *tavioka* in Fiji, ~ *manioka* in Samoa, ~ *manioc* in Vanuatu	**Description:** The cassava plant is a relatively new import to the Pacific and, given that it is easy to grow and simple to prepare, is becoming increasingly popular as a food and livestock fodder crop. Its nutritious leaves are eaten in some areas. Its starch-rich root is used in industry elsewhere in the world for glue-making and other industrial purposes. **Crop requirements:** Grows best in well-distributed rainfall setting of 1 000-1 500 mm/year. Higher rainfall levels can reduce tuber growth. It is considered highly tolerant of drought and can be grown in areas receiving as low as 500 mm/year. Cassava has low nutrient requirements and can be grown in relatively infertile soils. Hence it is often used as a final crop in rotations prior to returning land to fallow. It competes well with weeds but is sensitive to shade.

ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
SWEET POTATO *(Ipomoea batatas)* Know as: ~ *kumara* in Cook Islands ~ *umala* in Samoa, ~ *kumala* in Fiji, Tonga, ~ *kaukau* in PNG, ~ *te kaina* in Kiribati	**Description:** Sweet potato is a creeping plant and the only economically important species of the family Convolvulaceae. The starchy, tuberous roots are the major source of food, but the leaves are also a useful source of vegetable greens in some countries. In PNG, it is the major crop and staple food. It is also an important crop in the Solomon Islands and Tonga, and is increasingly found in other PICTs. **Crop requirements:** Grows best in high rainfall areas of about 1 500–2 500 mm/year. Higher rainfall may induce excessive vegetative growth at the expense of tuber growth. Grows well in a variety of well-drained soil types but does not tolerate shading.



ROOT CROP	GENERAL DESCRIPTION AND CROP REQUIREMENTS
YAMS *(Dioscorea alata, D. esculenta, D.bulbifera, D.pentaphylla, D.hispida, D.rotundata, and D.trifida, D. nummularia)* Known as: ~ *u'i* in Cook Islands, ~ *ufi* in Samoa, ~ *uvi* in Fiji, ~ *yam/mami* in PNG.	**Description:** Yams are a high value food that are easily grown and mature quickly in the right soil conditions. Unlike most other tropical root crops, yams exhibit good keeping qualities and may be harvested well in advance of eating. **Crop requirements:** Most varieties of yams grow best in rainfall of >1 500 mm/year and require a minimum 6-month growing season with well-distributed rainfall. Yams do not tolerate poorly drained soils or waterlogging. They are mildly drought tolerant but do not compete well with weeds for soil nutrients. Yams should be staked to improve yield, and reduce weed competition and the incidence of anthracnose disease. They exhibit early shade tolerance during establishment but require full sun for good yields.

PACIFIC FISHERIES

5.0 FISHERIES IN THE PACIFIC

Fish and fishing are culturally and economically critical for most PICTs and are a mainstay of food security in the region. The importance of the fisheries sector to the region's economy and food security is reflected by its reference in key regional strategies including *The Pacific Plan* and the *Vava'u Declaration on Pacific Fisheries Resources.* (See TOOLS 51 & 52.)

In the Pacific, a great variety of marine organisms are consumed. In Fiji, for example, over 100 species of finfish and 50 species of invertebrates are officially included in the fish market statistics, and many more species are believed to contribute to the diets of people in rural and urban areas of the Pacific. Fish[5] contributes substantially to subsistence and market-based economies and, for some of the smaller PICTs, fishing is their most important renewable resource.

Despite growing reliance on imported food products, subsistence fishing still provides the majority of dietary animal protein in the region, and annual per capita consumption of fish ranges from an estimated 13 kg in Papua New Guinea to more than 110 kg in Tuvalu (Table 5.1). According to forecasts of the fish that will be required in 2030 to meet recommended per capita fish consumption in PICTs (34-37 kg/year), or to maintain current consumption levels, coastal fisheries will be able to meet 2030 demand in only 6 of 22 PICTs. Supply is likely to be either marginal or insufficient in the remaining 16 countries, which include the region's most populous nations of Papua New Guinea, Fiji, Solomon Islands, Samoa and Vanuatu, as shown in Table 5.1. (See TOOL 50.)

Although parameters such as population growth and urbanization have been factored into these forecasts, the impacts of climate change are less well understood and introduce considerable uncertainty in the longer term. In essence, climate change represents a serious and multi-faceted risk to PICT fisheries that is likely to undermine the ongoing sustainability and management of the region's marine resources.

5 Fish is used here to represent both bony fishes and invertebrates.

Table 5.1: Estimated per capita current fish consumption (see bracketed figures where available, kg/year) and projected capacity of national coastal fisheries resources to fish demand in 2030

SUSTAINABLE PRODUCTION EXPECTED TO MEET FUTURE NEEDS	SUSTAINABLE PRODUCTION NOT EXPECTED TO MEET FUTURE NEEDS	SUSTAINABLE PRODUCTION ADEQUATE BUT DISTRIBUTION DIFFICULT
Cook Islands (34.9) Marshall Islands New Caledonia (25.6) Palau (33.4) Pitcairn Islands Tokelau	American Samoa Marianas Islands Fiji (20.7) Guam Nauru (55.8) Niue (79.3) PNG (13) Samoa (87.4) Solomon Islands (33) Vanuatu (20.3) Wallis & Fortuna (74.6)	FSM (69.3) French Polynesia (70.3) Kiribati (62.2) Tonga (20.3) Tuvalu (110.7)

Adapted from and Bell *et al.*, 2009 and SPC Policy Brief 1/2008. (See TOOLS 50 & 53.)

This module seeks to provide a simple overview of Pacific fisheries and the likely impacts of climate change, and then sets out some steps that PICT governments, planners and fishing sector stakeholders should consider to address the effects of climate change on the region's fisheries. Importantly, it also directs the reader to further tools available to help formulate climate change policies and adaptation measures.

5.0.1 Traditional coastal fisheries

The majority of fish consumed in the Pacific originates from coastal fisheries, which support a large variety of fish, shellfish, crustaceans and seaweeds that form an integral part of the diet of Pacific people. Apart from areas of mainland Papua New Guinea, virtually all Pacific Islanders live within the coastal zone and rely heavily on the coastal fisheries to supply fish for food. Despite the spread of modern fishing techniques, much of the inshore fishing in the region is still conducted by non-motorized small canoes or by wading and fishing in shallow inshore waters and lagoons. As well as being a source of food, fishing provides important income for many Pacific Island communities.

Fishing in coastal waters involves a wide range of techniques explained below.

Reef gleaning: The collection of marine animals and seaweeds at low tides from reefs and lagoons is an important source of food and livelihood, and a practice commonly undertaken by women and children. Species include sea cucumbers, sea urchins, crabs, shellfish, eels, seaweeds, octopus and finfish. The impact of reef gleaning can be substantial, particularly in highly populated coastlines.

Hooks, lures and lines: Fishing using hooks and lines is practiced throughout the region and range from simple hand-held lines to more elaborate long lines which aim to catch pelagic fish such as tuna and sharks. Lures towed behind boats are also used to catch pelagic species such as mackerel, dolphin-fish and tuna.

Spears: The use of spears is a traditional practice that has been modified in recent years with the advent of underwater flashlights. Species of reef fish that shelter near corals at night have become much easier targets for well-equipped fisherman kitted with modern masks, fins and spear guns.

Nets: There is a wide variety of nets used to catch coastal fish in the Pacific region including monofilament gill and barrier nets, beach seine nets, casting nets and scoop nets to name a few. Given their relatively low price, ease of use and high efficiency, the use of monofilament gill and barrier nets has proliferated in the Pacific. They are now widely used to target a range of fish species including mullet, shark, tuna and mackerel.

Traps: Barrier or fence trapping is one of the oldest forms of communal fishing and is still used commonly throughout the region to catch a variety of finfish.

(See TOOL 54 for further information on coastal fishing techniques)

5.0.2 Commercial fisheries

Offshore fisheries are one of the most important economic bases of many PICTs (see Table 5.2). Tuna, in particular, is a substantial component of both small-scale artisanal and large-scale commercial fisheries. Tuna fishing and transshipment, and access fees for foreign fishing activities represent an extremely valuable source of foreign exchange, especially for American Samoa, Kiribati, Fiji, Guam, the Northern Mariana Islands, the Marshall Islands, and the Federated States of Micronesia. Major fishing operations are also based in the exclusive economic zones (EEZs) of Papua New Guinea, Solomon Islands and Vanuatu.

Large-scale commercial fishing for tuna in the region is typically carried out by foreign fishing fleets originating from China, Indonesia, Japan, Korea, Philippines, Taiwan and USA. Many of these countries use highly effective modern fishing techniques that combine aerial and even satellite technology to find schools of skipjack and yellowfin tuna near the surface. The primary capture method used in the surface fishery is purse-seining, although some pole and line fishing still occurs. Long-lining is used to catch larger yellowfin tuna, bigeye tuna and albacore from deeper water.

Table 5.2: Estimated combined fish, crustaceans and mollusc capture in FAO Member States in the Pacific region

PACIFIC COUNTRY	FISH CAPTURE [tonnes/year]
Cook Islands	3 773
FSM	11 630
Fiji	46 891
Kiribati	31 000
Marshalls	42 019
Nauru	39
Niue	203
Palau	967
PNG	274 680
Samoa	3 340
Solomons	39 336
Tonga	2 500
Tuvalu	2 200
Vanuatu	88 075

Source: FAO, 2006

Currently, PICTs do not export a great deal of fishery products derived from their coastal fisheries. However, the export of sea cucumbers (known as *bêche-de-mer* in Melanesia and *trepang* in Micronesia), grouper, giant clam, green snail and other fish species have been important to some economies from time to time. In countries such as Fiji and PNG, there is also a growing trade in shells, corals and ornamental aquarium fish. Most small-scale, export-orientated coastal fishing is carried out by Pacific Islanders who sell their catches to foreign exporters. (See TOOLS 49 to 60.)

5.0.3 Freshwater fisheries

There is a lack of accurate information on the extent and value of freshwater fisheries in the Pacific. While freshwater fisheries do not exist in many smaller PICTs and low-lying atoll countries, they are thought to be contributing significantly to fisheries catches and food security in larger PICTs. In PNG for example, freshwater fish and invertebrate species are thought to provide much of the animal protein in inland areas. The importance of freshwater resources is demonstrated in PNG's Sepik River catchment, where more than 350 000 people live and catch up to 15 different species of freshwater fish for food. A range of local and introduced freshwater species, such as tilapia, eels Macrobrachium, prawns and mussels, are also harvested from lakes and rivers elsewhere in the region.

The freshwater fisheries of PNG are based on a broad range of river channel and floodplain habitats, fed by some of the highest levels of rainfall on Earth. Projected increases of rainfall in the tropics are expected to increase the extent and duration of flooding in PNG. Understanding is fairly limited of how increased flooding, turbidity and higher water temperatures will impact fish themselves and the lowland areas and rivers that support them. It is known, however, that freshwater fisheries throughout the region are based largely on species that migrate between the sea and freshwater. Accordingly, even small rises in sea level, temperature, rainfall and runoff may have impacts on habitats and fisheries in both estuarine and freshwater reaches of river systems. (See TOOL 49.)

5.0.4 Aquaculture in the Pacific

Aquaculture is the world's fastest growing food production system, growing at 7 percent annually. While aquaculture production in the Pacific region is relatively limited, it is considered to have great potential in many PICTs. (See TOOLS 61-65.) Historically the main producers have been New Caledonia, French Polynesia, Kiribati and the Cook Islands. However, highly populated inland areas of PNG probably hold the most potential. The principal types of aquaculture are explained below.

Open systems: Farmed species – such as pearl oysters, giant clams and seaweed – grow on lines or in nets or cages situated in coastal waters. These systems allow free exchange of nutrients, waste products, diseases, parasites and reproductive products between the farmed species and the coastal ecosystem.

Pond culture: Small-pond aquaculture is used in some countries, particularly within Melanesia, for the farming of milkfish and tilapia, and is considered to have considerable potential for expansion in the future. Although some larger, commercial ponds do exist within French Polynesia and Melanesia, they are almost exclusively targeted at shrimp production. The vast majority of pond culture operations in the Pacific region are relatively low-tech and focus on subsistence food production and livelihoods. These small-pond operations usually pose relatively little risk to surrounding ecosystems, but effluent waters and overspill can enter coastal waters, aquifers and adjacent streams, especially during flood events. Nutrient-rich effluent waters can pollute marine and freshwater resources, and introduce pathogens to wild fish populations.

In terms of food security, tilapia is arguably the easiest species to produce in small ponds and is the introduced freshwater fish species with the broadest appeal in the Pacific. (See TOOL 64.) Provided systems can be developed to distribute fingerlings effectively to remote areas, and suitable feeds based on local ingredients can be formulated, small-pond aquaculture has potential to contribute much needed animal protein to inland PNG and on high islands elsewhere in the region. (See TOOLS 61-65.)

5.0.5 Nutrition

Fish is an excellent source of protein and is naturally low in saturated fat and cholesterol. It contains essential dietary vitamins and minerals such as selenium, iodine and calcium. Oily fishes also have high levels of vitamins A and D and are rich in essential omega-3 fatty acids, which are important for growth and development. Omega-3 fatty acids found in fish are believed to have positive effects on the heart and blood vessels, and promote healthy vision and brain development in infants. These healthy fats have been linked to decreasing the risk of delivering a premature, low birthweight baby, and some studies even claim that omega-3 fatty acids may help protect against a range of other diseases including diabetes, cancer, Alzheimer's, depression and other mental disorders.

In addition to the many benefits of vitamins, minerals and omega-3 fatty acids, it is the role that fish plays as a source of dietary animal protein that makes it so important to PICTs. The World Health Organization (WHO) recommends that daily protein intake for good nutrition should be about 0.7 g of protein per kg body weight per day, derived from a variety of sources. In PICTs, where there is a strong tradition of eating fish and a limited range of crops and sources of animal protein, many PICTs will need to consume an average of 34–37 kg per person to meet 50 percent of the recommended protein intake for PICTs. (See TOOL 50)

5.1 THE IMPACTS OF CLIMATE CHANGE ON FISHERIES

While our understanding of how climate change will impact marine environments and fisheries is increasing, there remains an unacceptably high number of gaps in our knowledge given the huge role the world's oceans play in supplying food and maintaining ecosystem services to the planet. Ocean currents circulate massive volumes of cold and warm waters around the planet. The distribution of these waters and the nutrients they carry directly influences food availability for hundreds of millions of people. The currents also affect rainfall, wind patterns and storm behaviour, all of which have far reaching implications for land-based food production and the food and water security of billions of people.

The build-up of greenhouse gases in the Earth's atmosphere is impacting the marine environment in a number of ways. Fishery production losses are anticipated due to a combination of factors that are summarised in Table 5.3 and discussed in further detail below. (See TOOLS 49 to 65.)

5.1.1 Ocean warming and sea-level rise

The accumulation of greenhouse gases in the Earth's atmosphere is leading to an overall increase in average global temperature. The oceans are absorbing much of this heat and have warmed by about 0.7°C over the past century. This warming is causing thermal expansion of the oceans, the same process that sees roofing iron expand as it is heated by the sun during the day. Thermal expansion of the oceans, coupled with melting of glaciers and land-locked ice sheets, has already caused the oceans to rise by about 20 cm over the past century. The oceans are continuing to rise at a rate of about 3 mm/year and are predicted to increase by about 50 to 100cm or more by the end of the century.

Large sea-level rises have the potential to inundate critical fishing infrastructure including wharves, slipways, processing factories and low-lying aquaculture enterprises. They may also drown coral reefs, mangroves, sea grass banks, wetlands and estuaries – ecosystems that form the backbone of coastal fishery habitats and play multiple roles governing the production and distribution of coastal fish species and even deep-water commercial fin-fish species.

Table 5.3: Summarized impacts of climate change on Pacific fisheries and habitats

Ocean warming & sea-level rise	~ Coastal ecosystem inundation/decline ~ Coral bleaching ~ Reduced vertical mixing of nutrients ~ Changing currents & ranges of fisheries species
Ocean acidification	~ Reduced calcification by coral, molluscs and crustaceans ~ Coral reef & marine ecosystem declines
Changing storm and rainfall patterns	~ Increased incidence of drought and/or flooding ~ Increase turbidity of coastal waters ~ Coastal ecosystem destruction & decline
Changing environmental parameters	~ Changes in abundance of invasive pests and diseases

Increases in surface water temperatures can reduce vertical mixing of nutrient-rich cooler waters into the upper levels of the ocean. Such impacts disturb the complex food chains and migratory patterns that support commercial and subsistence fisheries alike. Nutrient distribution patterns are also affected by El Niño-Southern Oscillation (ENSO) events – the major source of inter-annual climate variability in the region. ENSO events strongly influence the production and distribution of phytoplankton and zooplankton within tropical and subtropical waters.

ENSO events are known to impact tuna fishing production, which is a billion dollar industry for the Pacific and the economic backbone of many smaller PICTs. During El Niño conditions, trade winds weaken and warm surface waters extend thousands of kilometres eastwards into the central and eastern Pacific. Skipjack tuna follow the warmer waters and catches increase in the central Pacific and decrease elsewhere. La Niña events are conversely characterized by cooler water conditions and strong trade winds.

A further impact of ocean warming is that of coral bleaching which occurs when coral reefs experience prolonged exposure to unusually warm surface waters. Exposure to waters 1 to 2°C warmer than usual for a period of 3 to 4 weeks can cause corals to expel symbiotic algae (zooxanthellae) that are responsible for their bright colours but more importantly much of their energy. Prolonged or repeated episodes of coral bleaching severely reduces the ability of corals to grow, reproduce and ward off diseases, and may ultimately result in the death of the host colony itself. The rate of global warming is projected to outstrip the capacity of many coral reefs in the Pacific to adapt. Accordingly, coral reefs are expected to lose structural complexity as some species fail to survive. There is real concern that many of the region's coral reefs will ultimately collapse and die as other stressors such as sea level rise, pollution, ocean acidification, increased turbidity and continuing over-exploitation combine to overwhelm these productive coastal ecosystems. (See TOOLS 49-74.)

5.1.2 Ocean acidification

The elevated carbon dioxide levels in the Earth's atmosphere are slowly but surely changing ocean chemistry – a process called ocean acidification. The ocean has absorbed about a third of the human carbon dioxide emissions since around 1750 and it is now more acidic than at any time during the last 650 000 years. Ocean acidification occurs when dissolved carbon dioxide reacts with seawater to form weak carbonic acid. This reduces the availability of the dissolved carbonate that is required by many marine-calcifying organisms, such as corals, shellfish and crustaceans to build their skeletons or shells. There is very real concern that continued emissions of carbon dioxide will drive sufficient gas into the oceans to cause under-saturation of carbonate in ocean waters. Under these conditions, coral reefs and marine animals and plants with carbonate skeletons and shells will struggle to fix sufficient carbonate out of the ocean waters. This will threaten their very survival and the balance of the many complex marine ecosystems that heavily rely on them for ecosystem services such as shelter, reproduction and food.

Global monitoring indicates that the Pacific Ocean has already acidified by 0.1 of a pH unit and is projected to acidify by a further 0.3-0.4 pH units by 2100. This level of acidification will significantly reduce carbonate saturation levels throughout much of the tropical and subtropical Pacific, causing many coral reefs there to collapse as they struggle to fix carbonates. The impacts of coral bleaching and ongoing pollution, mining and destructive fishing practices will further contribute to coral reef degradation in the region. (See TOOLS 66-74.)

5.1.3 Changing rainfall and storm patterns

As tropical oceans warm, it is projected that there will be greater evaporation and moisture availability leading to an intensification of the hydrological cycle, which may lead to increased rainfall in the tropical Pacific between 10°N to 10°S and decreased rainfall in the subtropics. Though the range and even direction of rainfall changes are still poorly understood, scientists do envisage that changes to the hydrological cycle are highly likely and will lead to intensified rainfall for some PICTs and the greater frequency of droughts for others.

Similarly, the 2007 IPCC assessment reports indicate that there is some likelihood that tropical cyclones may become more intense, resulting in heavier rainfall and larger peak wind speeds. (See TOOLS 8 & 9.) While there is presently no scientific consensus on this issue, any intensification, should it eventuate, would clearly place fishing infrastructure and ecosystems at greater risk and make open-sea fishing more hazardous.

Increasing rainfall and associated flooding will also threaten freshwater aquaculture enterprises. These risks would include losing fish from ponds during floods, invasion of ponds by unwanted species and damage to ponds through infilling and breaching of walls. On the other hand, heavier rainfall in low-lying tropical PICTs may provide some benefits in terms of potentially increasing areas suitable for rain-fed pond aquaculture. (See TOOLS 61-65.)

5.1.4 Ecosystem degradation

The aforementioned impacts of climate change are altering environmental conditions at such a rate that many of the region's marine and terrestrial ecosystems – key to fisheries production – will continue to decline and ultimately some may be lost altogether. The region hosts many fragile ecosystems that are vital to the sustainability of the region's fisheries. Coral reefs, mangroves, wetlands, coastal forests, estuaries and sea-grass beds are all highly susceptible to warming waters, changing currents, sea-level rise, ocean acidification and changes in sedimentation from changing rainfall patterns.

Unfortunately many of these ecosystems are already under considerable pressure from coastal land development; pollution of estuaries and lagoons by industrial wastes, fertilizers and pesticides; deforestation of erosion-prone coastal land and mangroves; and over-exploited coastal and deep-sea fisheries. Accordingly, the great concern is that climate change will act as a "threat-multiplier" and exacerbate existing environmental stresses.

While habitat destruction of coastal and marine ecosystems such as mangroves and corals reefs has obvious implications for fisheries, other effects of climate change may be more subtle but equally detrimental to the region's fisheries. Warming waters are likely to force slow migration of some fish species to cooler waters either further to the north or south of the equator. Less adaptable species that live around reefs will find their ecological niches shrinking and possibley disappearing all together. As environmental conditions change, ecosystems may become vulnerable to outbreaks of marine invasive species and diseases. Changing currents may also impact the dispersal of fish larvae and the connectivity among neighbouring fish populations in different areas.

While not all fish species will decline with climate change – some species may actually flourish as their ecological niches expand – there is growing concern that the overall impacts of climate change on Pacific fisheries and the region's food security will be negative. This is partially due to the region's strong reliance on vulnerable coastal fisheries but is also a reflection of the limited adaptive capacity of small and isolated PICTs to change fishing practices and modes of production. (See TOOLS 49-65.)

5.2 ADAPTING TO THE IMPACTS OF CLIMATE CHANGE

This section provides some keys steps that PICT governments, communities and/or individuals may consider to reduce the present and pending impact of climate change on Pacific fisheries. They range from high-level policy steps to smaller practical steps that may be undertaken by communities and individuals.

Given the large degree of uncertainty associated with how fish populations, habitats and migratory patterns will change with time, the steps provided below take a regional and non-prescriptive approach that focuses on sound environmental management and diversifying fish production practices in the Pacific. The list of steps is not exhaustive but is rather designed to prompt ideas, discussion and action, and draw the reader's attention to further tools and resources provided at the end of the module.

5.2.1 Addressing planning and climate change mainstreaming

The role of PICT governments and regional institutions will be critical in helping the region build stronger, more diversified and climate-resilient Pacific fisheries. It will require national fisheries agencies, FAO, and regional agencies such as the Secretariat of the Pacific Community (SPC), and the Forum Fisheries Association (FFA) to focus more resources on research, capacity building and education initiatives in the areas of coastal fisheries and aquaculture. To date, much of the effort has focused on high-value migratory commercial species – principally tuna.

A more diversified fisheries production base will essentially spread the risk of climate change and hopefully help identify those practices or production modes that are favoured, or at least, not as strongly affected by climate change. Other environment-focused regional organizations such as the Secretariat of the Pacific Regional Environment Programme (SPREP), NGOs and UN agencies also have a critical role to play in developing strategies and programmes, and promoting the protection of terrestrial and marine ecosystems that are integral to sustaining fish production in the Pacific.

Careful planning and the revision of existing fisheries policies to factor in the impacts of climate change and to diversify production vehicles will be critical to building a more resilient fishing sector. The following steps are focused on climate change "mainstreaming" activities that are designed to ensure that the impacts and causes of climate change are fully considered in all government policies and development initiatives.

- **Step 31 –** Stakeholders and communities should call for, and support, PICT governments to mainstream climate change adaptation and mitigation efforts and food security into national development strategies, fisheries sector plans and policies. Care should be taken to ensure the following.
  - Existing and newly developed fisheries plans and policies take a conservative, precautionary approach to managing marine resources and that they are responsive to the uncertainties of climate change and future food security needs.
  - The plans draw on the principals of ecosystem-based fisheries management which factor in the broader effects of fishing on the environment, as well as its impacts on other sectors, such as tourism, and the importance of marine conservation and integrated coastal management.
  - PICT governments should develop fishery management plans for coastal fisheries and, where appropriate, for aquaculture. These plans should be developed in a highly consultative way, incorporate indigenous technical knowledge and promote community-based fisheries management or co-management approaches. They should also complement customary marine tenure systems.
  - PICT governments should look to eliminate subsidies that may encourage over fishing and excess fishing capacity. Fuel-efficient fishing and aquaculture practices should be promoted.
  - PICT governments should look to develop and apply environmental impact assessment procedures to all activities and processes that may have an impact on marine ecosystems, including fishery, aquaculture and seafood processing projects.

- **Step 32 -** To secure sustainable levels of fish for food security in PICTs, national fisheries agencies with the support of regional and multilateral organizations will need to promote fisheries polices that improve access to fish for rural communities and growing urban populations. The key ways to do this are the following.
  - Manage coral reef fisheries to maximize their sustainable yields to ensure that the gap emerging between the fish that reefs can supply and the fish needed for food by growing human popualtions is no greater than it needs to be.

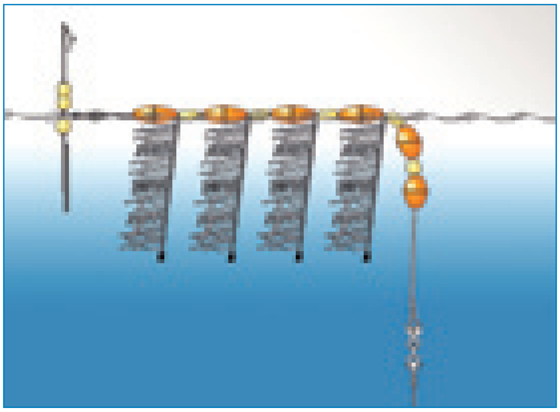


photo: ©Tim Pickering

Left: **the installation of low-cost Fishing Aggregating Devices (FADs) have been shown to improve inshore tuna catches and reduce the need for subsistence fishers to venture far offshore in often inadequately equipped, small boats.** **Right:** **Mozambique tilapia pond constructed by Mr Fred Manu at Manakwai Village in North Malaita, Solomon Islands.**

- Reallocate a proportion of national tuna catches for domestic consumption to meet food security needs. This may include the sale of low export value tuna (e.g. undersized fish and by-catch from commercial fishing fleets) on PICT domestic markets to strengthen food security for rapidly growing urban populations.
- Establish low-cost, inshore fish aggregating devices (FADs) and develop small-pond and larger aquaculture operations. The allocation of land and waters resources for aquaculture should be factored into land-use plans.

- **Step 33 –** Governments should ensure that fisheries and aquaculture are blended into national climate change adaption strategies. Failure to do so may see aquatic systems, fisheries and aquaculture potentially suffer as the result of adaptation measures applied by other sectors, such as the increased use of dams for water capture and hydropower, or the construction of artificial coastal defensives.

- **Step 34 –** Governments, regional agencies and development partners should work collaboratively to strengthen human and institutional capacity to identify climate change risks to Pacific fisheries and to develop, implement and monitor appropriate adaptive measures. (See TOOLS 49-83.)

5.2.2 Combating information gaps

Much of the global climate change research conducted to date on fisheries and marine ecosystems has focused on tuna (big-eye, albacore, skipjack and yellowfin) and on coral reefs. There has been comparatively little research conducted on the impacts of climate change on Pacific coastal fisheries, and the coastal ecosystems that support them.

Here are some steps that could help to ensure that we have up-to-date and best practice information available to fishing stakeholders and decision-makers in the Pacific region.

- **Step 35** – Awareness among stakeholders of the probable impacts of climate change on fisheries, and marine and coastal ecosystems is required at all levels. Relevant stakeholders should also be made aware of the adaptive steps (and underlying strategies) available to maintain and enhance fisheries production in the Pacific region.

- **Step 36** – PICTs need to call for and support climate change-focused research that both models the effects of climate change on Pacific fisheries and also seeks to identify practical village-level solutions to adapting to climate change. The research gaps are numerous but some key ones have been identified. (See TOOL 1.)
  - Increase high-quality observations of oceanographic conditions and surface weather for PICTS. Such observations will help shed light on how rapidly these systems are changing and how these changes will impact marine ecosystems and fisheries.
  - Downscale climate change and oceanographic modeling to "island-scale" resolution to facilitate a more accurate assessment of the local sensitivity and vulnerability of PICTs to changing ocean and climate conditions.
  - Prepare inventories of vegetated coastal habitats, including their connectivity to coral reefs, and environmental thresholds for growth and survival, to help identify links to fisheries productivity.

- Improve baseline information on the size and composition of coastal and inland fishery landings across the region, in order to assess climate change impacts and the success of adaptation measures.
- Improve modeling of the responses of key tuna species to climate change to identify and understand the projected fishing effort and interactions among tuna species. These models also should include descriptions and long-term observations of the relationships between tuna populations and the abundance of plankton and micronekton upon which tuna sometimes feed.
- Guide efforts towards identifying locations suitable for the establishment of low-cost inshore FADs.
- Improve the management of freshwater fisheries and facilitate the expansion of pond aquaculture in PICTs. This requires research and modeling to assess*: (i)the habitat and freshwater flow requirements, and connectivity needed to sustain river and estuary-based fisheries; (ii) projected changes in the area and availability of floodplain habitats for fisheries production and pond aquaculture; and (iii) how climate change may increase the incidence of pathogens for important aquaculture species.*
- Undertake research and development to adapt and improve fishing practices, equipment and baits to reduce by-catch and to improve targeting of desirable fish species.

- **Step 37 –** To ensure climate change-focused fisheries research is successful, it should be strongly targeted at resource conservation but must also address the food security and livelihoods requirements of fishers. Where practicable, research should draw upon the skills and expertise of subsistence fishers and other key fisheries stakeholders at all stages of the research process.

- **Step 38 –** A regional approach to the sharing of climate change adaptation initiatives and lessons learned is critically important to building Pacific expertise on fisheries that can be shared among neighbouring countries. (See TOOLS 11-22 & 49-83.)

5.2.3 Adaptations for tuna fisheries

Warming ocean temperatures and changes to currents and food chains in the open ocean are projected to affect the location and abundance of tuna in the Pacific. Preliminary research indicates that the concentrations of skipjack and big-eye tuna are likely to shift further eastward in the Pacific under climate change. The shift of tuna stocks eastward may represent a windfall to smaller resource-poor countries such as Kiribati, Tuvalu and Tokelau in the central Pacific. Conversely, Melanesian countries and the Federated States of Micronesia and Nauru may lose valuable revenue from falling catches, and lower licence fees from distant water fishing nations to fish in their Exclusive Economic Zones. Reduced catches may also affect the profitability of national canneries and processing plants.

The impacts of climate change on long-lining operations is less well understood but there is some evidence to suggest that stocks of yellowfin and albacore tuna may also gradually shift eastwards away from traditional fishing grounds. While little can be done to control the future migratory patterns of tuna, there are some practical steps that nations can take to build the resilience of national tuna industries and to strengthen food security.

~ **Step 39 – PICTs should strictly adhere to international treaties and conventions aimed at sustaining tuna stocks. PICTs should also seek and bide by the advice generated by regional agencies that are tailored towards sustaining regional tuna stocks.**

~ **Step 40 – New and existing shore-based fishing infrastructure, such as canneries and wharves, should be assessed and, where necessary, upgraded to withstand greater intensity cyclones and rising sea levels. Upgrading work should factor in projected changes to tuna migratory patterns and associated processing demand. Some boats will also need to be replaced or upgraded to meet changing occupational safety requirements in an ocean that may experience more extreme weather events and intensified storm activity.**

- **Step 41 – The establishment of low-cost inshore FADs in rural areas would serve to improve tuna catches for rural populations and reduce the need for subsistence fishers to venture far offshore in search of tuna in often inadequately equipped, small boats.**

- **Step 42 – The domestication of tuna fisheries may provide some PICTs with an opportunity to increase the long-term sustainability of their tuna resources, while improving national food security and providing local jobs.**

- **Step 43 – Methods to increase the shelf life of tuna caught on inshore FADs should be developed and disseminated to subsistence fishers. Focus must be given to handling, hygiene and cold-chain storage practices, and the development of low-cost preservation methods such as drying and smoking.** (See TOOLS 49-60.)

5.2.4 Adaptation for coastal fisheries

Climate change is projected to cause significant changes to the availability and relative abundance of the fish and invertebrates that currently support coastal fisheries in the Pacific. The loss of structural and biological complexity on coral reefs will have profound effects on the types of fish and invertebrates associated with them. For example, fish species that depend on live coral for food, and on the intricate variety of shelter created by structurally complex reefs for their survival, are eventually likely to disappear. Effects of climate change on coastal fisheries associated with coral reefs may not be immediately apparent, but result in slow, long-term declines in yields as resilience and productivity are gradually eroded.

The decline of coral reefs is not the only factor that will affect coastal fisheries resources. Depending on the location of PICTs, projected increases in air and sea surface temperatures, sea level, cyclone intensity and turbidity of coastal waters due to higher rainfall can be expected to affect the growth and survival of mangroves, sea grasses, wetlands and the nature of intertidal and sub-tidal sand and mudflat areas. Although the role that these habitats play in supporting fisheries production in the Pacific is poorly understood compared to that of coral reefs, there is evidence that these ecosystems provide important nurseries for juvenile fish and important breeding and feeding grounds for a wide range of coastal fish species.

Given the vital role that coastal fisheries play in subsistence life throughout the Pacific (See TOOL 50), one of the greatest impacts that climate change is likely to have is on food security. If future production of fish from coral reefs and the other coastal habitats decreases, or is comprised of fish not readily accepted as food by local communities, the emerging gap in the fish needed for food security will increase.

The following steps provide some recommendations to help sustain coastal fisheries in the bow-wave of climate change.

~ **Step 44 – In addition to addressing the present and pending impacts of climate change, PICT governments and communities must also urgently address the ongoing impacts of: *mining; deforestation; ocean-based disposal of domestic and human wastes; poorly planned coastal development; and the over exploitation and abuse of Pacific fisheries through destructive and unsustainable fishing practices, such as the use of explosives and poisons.* Examples of these unsustainable activities can be found throughout the region and their impacts must not be thrown into the "climate change basket" which appoints blame elsewhere. To date, addressing these threats under the banner of climate change has been marred by lack of international action.**

~ **Step 45 – The strengthening of simple community-based measures aimed at sustaining coastal fisheries is critical. These measures may include the establishment of marine reserves; the protection of vulnerable species and/or spawning fish; village-enforced short- and long-term harvesting restrictions; setting species-specific minimum size-limits; regulation and banning of some forms of fishing methods, such as spearfishing at night, spearing crayfish, and the use of poisons and explosives. Failure to act locally will ultimately lead to overfishing and destabilized ecosystems vulnerable to environmental change, diseases and pests.**

~ **Step 46 –** Community-based sustainable fisheries measures should be coupled with national fishing regulations. These higher-level measures should reinforce community-based fisheries management in a way that prevents overfishing, promotes community ownership and management of marine resources, and provides a safety net where devolving management to the local level encounters difficulty. They must also strongly consider and complement customary marine tenure systems that prevail throughout most PICTs.

~ **Step 47 –** National fisheries agencies should look to work with communities to undertake baseline surveys and to establish simple indicator-based monitoring systems to ensure that fish harvesting rates are sustainable. Examples of simple indicators may include: density of target species per unit area of habitat; body mass; and catch per unit of effort.

~ **Step 48 –** Where practicable, PICT governments should consider the allocation of dedicated fishing grounds for rural communities and promote rights-based fishing as opposed to a "free for all" fishing approach. This may serve to improve local governance and sustainable management of marine resources and reduce resource exploitation by "outsiders". In many PICTs, such an approach may involve supporting and re-establishing customary marine tenure systems.


photo: ©James Ngwaerobo


photo: ©SPC

Aquaculture is thought to hold strong potential for improving food security partilcularly in the Melanesian Countries. Species such as Nile tilapia (pictured) grow rapidly and can provide an important source of protein for inland populations.

~ **Step 49 –** PICTs and regional organizations should promote the importance of maintaining healthy and self-replenishing fisheries to fishing communities. Such work should stress the need to manage fisheries sustainably, and the interconnectedness of the marine and terrestrial ecosystems that support them. This concept of co-dependence draws strongly upon the principals of ecosystem-based fisheries management.

~ **Step 50 –** The role of tidal flats, wetlands, coastal forestry and mangroves in supporting fisheries resources is often grossly undervalued. These ecosystems play multiple and important roles in sustaining coastal fisheries and food security. Governments and communities must act to protect these fragile ecosystems against deforestation, land reclamation and other destructive development initiatives.
  ~ Mangroves, coastal forests and wetlands act as important buffers between the land and sea. They help prevent silt-laden and polluted surface waters from reaching fragile marine environments and, conversely, protect land resources against the ravages of wave action, cyclones, storm surges and rising sea levels.
  ~ Coastal vegetation combats climate change by trapping carbon dioxide which can remain locked away in the cellulose of plants for many decades or even hundreds of years.

5.2.5 Adaptation for aquaculture and freshwater fisheries

The impacts of climate change are predicted to impact aquaculture and freshwater fisheries in a multitude of ways. For example, many low-lying areas and flood plains that are suited for aquaculture will become increasingly impacted by rising sea levels, storm surges and rain-induced flooding as the impacts of climate change take hold in the Pacific region. Increased flooding will impact aquaculture operations by dispersing brood stock, eroding and infilling ponds, and damaging adjacent pumps and infrastructure.

Likewise, increased flooding and associated erosion and silting of rivers, streams and lakes will adversely impact freshwater fisheries. Effective land-use planning will be critical to help in identifying areas suited for aquaculture and to help protect forests

Figure 5.4: **Mangroves and coastal forests play an important role in protecting fisheries and coral reefs from the damaging effects of sedimentation and pollution. In this picture, silt from steep, erosion-prone land has been washed into the ocean. Effective land-use planning and the retention of forested zones between the land and the sea could have helped avoid this ongoing damage to the nearby coral reef.** (See TOOLS 49-83.) (Vava'u 2009)

photo: ©R. Sands

and water resources and fish habitats within vulnerable catchments. Drought also may impact some PICTs with obvious consequences to both freshwater fisheries and aquaculture operations.

Open aquaculture systems that are based in coastal waters will also need to consider the increased risks to infrastructure associated with possible increases in storm and cyclone intensity in some PICTs. Change in salinity levels and water temperature is also likely to affect the viability of farming some species of seaweed such as kappahycus or *cottonii*. In the case of kappahycus, higher water temperatures combined with lowered salinity (from increased rainfall) may trigger outbreaks of epiphytic filamentous algae (EFA) and *ice-ice* disease in some PICTs. Both of these diseases can substantively reduce kappahycus production.

Unregulated mining of sands, corals and rocks from beaches is a common practice throughout the Pacific region. Indescriminant mining can increase erosion, siltation and degradation of coastal ecosystems that form vital nurseries and habitats for a wide variety of fish species.

While many scientists predict that climate change will have an overall negative impact on Pacific aquaculture operations, not all impacts will be harmful. In contrast to the projected declines for PICT agriculture, climate change may open new opportunities for aquaculture as seas encroach on coastal lands, as more dams and impoundments are constructed in river basins to buffer the effects of changing rainfall patterns and droughts and to harness hydropower, and as urban waste demands more innovative disposal. With land-based aquaculture there may also be more scope to engineer solutions to climate change impacts, particularly in larger scale commercial operations, where water temperatures and water quality can be altered through filtration and reticulation systems. Presented below is a series of steps aimed at protecting Pacific island ecosystems and the freshwater fisheries and aquaculture operations they host.

~ **Step 51** – While it is unrealistic to think that climate change-induced coastal erosion in PICTs can be totally prevented, it is important to reduce human activities that further contribute to coastal erosion processes. Activities such as the mining of corals and sand, the development of coastal infrastructure, and the deforestation and degradation of coastal forests, mangroves and wetlands must be closely regulated.

~ **Step 52** – Land-based aquaculture initiatives should be located carefully to reduce the risk of flooding and/or inundation. It may be possible to climate-proof existing aquaculture infrastructure by installing effective drainage systems, reforesting catchments and by upgrading ponds and buildings to withstand higher intensity storms and heavier rainfall.

~ **Step 53** – In subtropical and atoll countries that may become increasingly impacted by drought, the installation and/or up-scaling of water capture and storage facilities may be necessary to maintain or develop aquaculture productions levels and processing capacity.

~ **Step 54** – Aquaculture operations should incorporate effective aquatic biosecurity practices and regulations to avoid the introduction of alien and invasive species, diseases, parasites or other unwanted species along with imported broodstock. They also must avoid poor husbandry practices, such as overstocking, which can cause diseases or parasitic infections that have the potential to devastate production and infect wild fish populations.

~ **Step 55** – Aquaculture operations that source juvenile brood stock from the wild, and fish and other marine organisms for production feed must ensure that their practices do not overfish or degrade natural fisheries and the broader environment. (See TOOLS 49-65.)

TOOLS
WHERE TO GO TO FIND OUT MORE

CLIMATE CHANGE AND FOOD SECURITY TOOLS

TOOL 1	CLIMATE CHANGE AND FOOD SECURITY IN PACIFIC ISLAND COUNTRIES
DESCRIPTION	Book presenting overview of climate change and food security issues in the Pacific with a focus on case-studies conducting in the Cook Islands, RMI and Vanuatu.
TOOL TYPE	Book
YEAR	2008
FOCUS	Food security and adaptation
SCOPE	Pacific Island countries with focus on Cook Islands, RMI and Vanuatu
REFERENCE/LINKS	Published by FAO Rome. Web site: www.fao.org/sids

TOOL 2	FAO CLIMATE CHANGE AND FOOD SECURITY: A FRAMEWORK DOCUMENT
DESCRIPTION	This paper takes a broader view and explores the multiple effects that global warming and climate change could have on food systems and food security. It also suggests strategies for mitigating and adapting to climate change in several key policy domains of importance for food security.
TOOL TYPE	Policy Framework
YEAR	2008
FOCUS	Food security and climate change
SCOPE	Global
REFERENCE/LINK	Food and Agriculture Organization of the United Nations, Rome 2008 www.fao.org/clim/index_en.htm

TOOL 3	CLIMATE CHANGE AND FOOD SECURITY IN THE PACIFIC
DESCRIPTION	Policy Brief discussing food security and climate change in the Pacific and recommended actions to address food security in the face of climate change.
TOOL TYPE	Policy Brief
YEAR	2009
FOCUS	Food security and adaptation
SCOPE	Pacific Island countries
REFERENCE/LINK	ftp://ftp.fao.org/docrep/fao/012/i1262e/i1262e00.pdf

TOOL 4	FAO CLIMATE CHANGE WEB SITE
DESCRIPTION	Web site focusing on the impacts of climate change on agricultural and fisheries. Provides links to numerous online resources.
TOOL TYPE	Web site
YEAR	2010
FOCUS	Climate change and food security
SCOPE	Global
REFERENCE/LINK	http://www.fao.org/climatechange/en/

TOOL 5	CLIMATE CHANGE AND FOOD SECURITY IN PACIFIC ISLAND COUNTRIES
DESCRIPTION	Policy Brief prepared by the Secretariat of the Pacific Regional Environment Programme and University of the South Pacific, in cooperation with the FAO Sub-Regional Office for the South Pacific in Samoa. Prepared for High-level Conference on World Food Security: The challenges of climate change and bioenergy.
TOOL TYPE	Policy Brief
YEAR	2008
FOCUS	Climate change and food security
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.fao.org/fileadmin/user_upload/foodclimate/forum/CCandFSinPIC.pdf

CLIMATE CHANGE TOOLS

TOOL 6	CLIMATE CHANGE IN THE PACIFIC
DESCRIPTION	Resource book discussing impacts and potential actions to combat climate change in the Pacific region.
TOOL TYPE	Book
YEAR	2003
FOCUS	Climate change impacts and actions in the Pacific
SCOPE	Pacific Islands
REFERENCE/LINKS	WWF Regional Office. Email: info@wwfpacific.org.fg

TOOL 7	THE COMPLETE GUIDE TO CLIMATE CHANGE
DESCRIPTION	Taking you through the A-to-Z of the key scientific, geographical and socio-political issues involved in the study of the environment and the implications of humankind's effect upon it, to PICTs covered include: ~ Environmental Science – the Carbon Cycle and the "Greenhouse Gases" ~ The impacts of climate change on life, land and sea ~ Mitigation strategies from carbon capture to carbon taxes ~ The Kyoto Protocol and UNFCC ~ Renewable fuel sources, from wind to solar power.
TOOL TYPE	Book
YEAR	2008
FOCUS	Climate change
SCOPE	Australia
REFERENCE/LINKS	B. Dawson & M. Spannagle (2008). Published by Routledge ISBN: 978-0-415-47790-1

TOOL 8	IPCC CLIMATE CHANGE SYNTHESIS REPORT 2007
DESCRIPTION	Summarizes the findings of the three IPCC Working Group reports (Group I: Physical Science Basis; Group II: Impacts, Adaptation and Vulnerability; Group III: Mitigation of Climate Change) and provides a synthesis that specifically addresses the issues of concern to policy-makers in the domain of climate change.
TOOL TYPE	Report
YEAR	2007
FOCUS	Climate change science, adaptation and mitigation
SCOPE	Global
REFERENCE/LINK	IPCC, 2007. Climate change 20007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 104 pp. http://www1.ipcc.ch/ipccreports/assessments-reports.htm

TOOL 9	IPCC CLIMATE CHANGE FOURTH ASSESSMENT REPORT: WORKING GROUP II REPORT ON "IMPACTS, ADAPTATION AND VULNERABILITY"
DESCRIPTION	IPCC 4AR Working Group II includes chapters on climate change impacts and adaptation measures for SIDs and food production systems.
TOOL TYPE	Report
YEAR	2007
FOCUS	Climate change adaptation
SCOPE	Global
REFERENCE/LINK	Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html

TOOL 10	COP 15 SYNTHESIS REPORT – CLIMATE CHANGE: GLOBAL RISKS, CHALLENGES & DECISIONS
DESCRIPTION	Synthesis report prepared prior to COP 15 meeting in Copenhagen. Presents an up-to-date overview of a broad range of research relevant to climate change – including fundamentals climate science, the impacts of a changing climate on society and environment, and the many tools and approaches available to deal effectively with the challenge of climate change.
TOOL TYPE	Report
YEAR	2009
FOCUS	Climate Change
SCOPE	Global
REFERENCE/LINK	http://www.climatecongress.ku.dk

CLIMATE CHANGE ADAPTATION TOOLS

TOOL 11	SPREP CLIMATE CHANGE PORTAL & CLIMATE CHANGE FACTSHEETS
DESCRIPTION	Web site including numerous pages and factsheets discussing adaptation and mitigation issues and initiatives in the Pacific region.
TOOL TYPE	Web site
YEAR	2009
SCOPE	Pacific Region
REFERENCE/LINK	http://www.sprep.org/climate_change

TOOL 12	SURVIVING CLIMATE CHANGE IN SMALL ISLANDS – A GUIDEBOOK
DESCRIPTION	This guidebook provides information about the risks associated with climate change, as well as providing ideas, tools and techniques for those who need to start taking action today to prepare. It is primarily aimed at government officers who would like to learn more about climate change, its impacts and how to start preparing. Specifically, it has been written to facilitate incorporation of climate change into planning and development activities on small islands. The general approach described is also useful for other geographic locations; enabling any reader to apply the recommendations and develop their own climate change adaptation plans.
TOOL TYPE	Guidebook
YEAR	2005
FOCUS	Climate change adaptation
SCOPE	SIDS
REFERENCE/LINKS	http://www.tyndall.ac.uk

TOOL 13	UNFCCC LOCAL COPING STRATEGY DATABASE
DESCRIPTION	This database is intended to facilitate the transfer of long-standing coping strategies/mechanisms, knowledge and experience from communities that have had to adapt to specific hazards or climatic conditions to communities that may just be starting to experience such conditions, as a result of climate change.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Adaptation
SCOPE	Contains limited Pacific-specific case studies but SIDS case studies included.
REFERENCE/LINK	UNFCCC Web site: http://maindb.unfccc.int/public/adaptation

TOOL 14	SHIFTING TIDES CLIMATE CHANGE ACTION KIT
DESCRIPTION	This kit was conceived to raise awareness of the impacts of climate change on indigenous communities in Canada and in the South Pacific. Indigenous communities are particularly vulnerable to the social and economic impacts of climate change due to the nature of their subsistence-based economies and colonial histories.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Mitigation
SCOPE	Canada and Pacific
REFERENCE/LINK	Pacific People's Partnership http://climatechange.pacificpeoplespartnership.org

TOOL 15	PACIFIC REGIONAL INTEGRATED SCIENCE AND ASSESSMENT (PACIFIC RISA)
DESCRIPTION	Pacific RISA programme supports Pacific island and coastal communities to mitigate and adapt to the impacts of climate variability and change. The Pacific RISA emphasizes the engagement of communities, governments, and businesses in developing effective policies to build resilience in key sectors such as water resource management, coastal and marine resources, fisheries, agriculture, tourism, disaster management and public health.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Mitigation and adaptation
SCOPE	The primary geographic focus of the Pacific RISA climate programme is the USA Pacific Islands (Hawaii, Guam, American Samoa, Northern Mariana Islands, Federated States of Micronesia, Marshall Islands, and Palau), networked with Pacific regional partners located in Fiji, Samoa, New Zealand, Australia and the USA mainland.
REFERENCE/LINK	East-West Centre Hawaii http://www.pacificrisa.org/cms

TOOL 16	GRID-ARENDAL
DESCRIPTION	GRID-Arendal is a collaborating centre of the United Nations Environment Programme (UNEP). Established in 1989 by the Government of Norway as a Norwegian Foundation, its mission is to communicate environmental information to policy-makers and facilitate environmental decision-making for change.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Mitigation with useful graphics
SCOPE	Global
REFERENCE/LINK	http://www.grida.no

TOOL 17	ASSESSING THE VULNERABILITY OF RURAL LIVELIHOODS IN THE PACIFIC TO CLIMATE CHANGE
DESCRIPTION	This report details a ten-month scoping study conducted to assess the relative vulnerability of rural livelihoods across PICTs to climate change. The study focuses on East Timor (Timor-Leste) and 15 PICTs (Federated States of Micronesia (FSM), Kiribati, Marshall Islands, Palau, Fiji, Nauru, Solomon Islands, Papua New Guinea, Vanuatu, Cook Islands, Niue, Samoa, Tokelau, Tonga, Tuvalu) and seeks to synthesize existing knowledge obtained from previous assessments of the vulnerability of rural livelihood stakeholders to climate change, together with context-specific knowledge contributed from stakeholders living in and around the Pacific, and working in the area of climate change.
TOOL TYPE	Report
YEAR	2009
FOCUS	Pacific Island countries
REFERENCE/LINK	Park, S., Howden, M., Booth, T., Stokes, C., Webster, T., Crimp, S., Pearson, L., Attard, S. Jovanovic, T. (2009). Assessing the vulnerability of rural livelihoods in the Pacific to climate change Prepared for the Australian Government Overseas Aid Programme (AusAID). CSIRO Sustainable Ecosystems, Canberra. http://www.rfdalliance.com.au/site/phase_1_-_climate_change_project_3.php

TOOL 18	ADAPTATION LEARNING MECHANISM
DESCRIPTION	The ALM draws from experiences on the ground, featuring tools and practical guidance to meet the needs of developing countries. Seeking to provide stakeholders with a common platform for sharing and learning, the ALM complements the wide range of adaptation knowledge networks and initiatives already underway. For example, the ALM is collaborating with the Nairobi Work Programme, particularly the "Methods and Tools" and "Planning and Practices" areas of work, and the interactive weADAPT platform.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Climate change adaptation and knowledge transfer
SCOPE	Global
REFERENCE/LINK	http://adaptationlearning.net

TOOL 19	ECOSYSTEMS, LIVELIHOODS AND DISASTERS: AN INTEGRATED APPROACH TO DISASTER RISK MANAGEMENT
DESCRIPTION	This IUCN publication provides recommendations for making disaster risk reduction strategies more effective.
TOOL TYPE	Book
YEAR	2006
FOCUS	Disaster risk management
SCOPE	Global
REFERENCE/LINK	http://data.iucn.org/dbtw-wpd/edocs/CEM-004.pdf

TOOL 20	THE NIUE DECLARATION ON CLIMATE CHANGE
DESCRIPTION	The Niue Declaration on Climate Change was endorsed by Pacific leaders at the 39th Pacific Island Forum held in Niue in August 2008. It is a key document in the region's efforts to address climate change in the Pacific region.
TOOL TYPE	Declaration
YEAR	2008
FOCUS	Climate change
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.forumsec.org.fj/pages.cfm/newsroom/press-statements/2008/forum-leaders-endorse-niue-declaration-on-climate-change.html

TOOL 21	PACIFIC ISLANDS FRAMEWORK FOR ACTION ON CLIMATE CHANGE (PIFACC-2005) & ACTION PLAN FOR THE IMPLEMENTATION OF THE PACIFIC ISLANDS FRAMEWORK FOR ACTION ON CLIMATE CHANGE (2008)
DESCRIPTION	Framework sets out issues and response measures to address climate change in the Pacific region.
TOOL TYPE	Regional framework
YEAR	2005/2008
FOCUS	Climate change adaptation and mitigation
SCOPE	Pacific region
REFERENCE/LINK	Secretariat of the Pacific Regional Environment Programme. www.sprep.org/climate_change/pycc/documents/PIFACC.pdf

PACIFIC FOOD SYSTEMS & ROOT CROP TOOLS

TOOL 22	SUSTAINABLE RUMINANT LIVESTOCK PRODUCTIONS IN THE SOUTH PACIFIC REGION
DESCRIPTION	Academic paper focusing on sustainable livestock production in the South Pacific region.
TOOL TYPE	Conference proceedings
YEAR	2001
FOCUS	Livestock production
SCOPE	Pacific Island countries
REFERENCE/LINK	Aregheore, E.M., Umar, M., and Adams E. (Eds) (2001) Sustainable Ruminant Livestock Productions in the South Pacific Region. Proceedings of an IRETA workshop. 25 June – 2 July 2001, Peninsula Hotel, Suva, Fiji. Published by the Institute for Research, Extension & Training in Agriculture (IRETA). University of the South Pacific, Alafua Campus, Samoa.

TOOL 23	FOOD PRODUCTION IN THE SOUTH PACIFIC
DESCRIPTION	Booklet provides an overview of traditional and modern food production systems in the Pacific.
TOOL TYPE	Academic paper
YEAR	1976
FOCUS	Pacific food production
SCOPE	Pacific Island countries
REFERENCE/LINK	Fisk, E.K., Hardaker, J.B. & Thaman, R.R. (1976). Food Production in the South Pacific. The R.W. Parkinson Memorial Lectures. The University of the South Pacific, Suva, Fiji Islands. Book 51 pp.

TOOL 24	AGRICULTURAL DEVELOPMENT IN THE PACIFIC ISLANDS IN THE 1990s
DESCRIPTION	Proceedings of a conference on agricultural development in the Pacific Islands in the 1990s.
TOOL TYPE	Academic paper
YEAR	1989
FOCUS	Sustainable agricultural development
SCOPE	Pacific region
REFERENCE/LINK	Haynes, R.J. & Naidu, R. (1989) Proceedings of an international conference and workshop held in Suva, Fiji on 31 March and 1 April 1989.

TOOL 25	THE REGIONAL IMPACTS OF CLIMATE CHANGE: AN ASSESSMENT OF VULNERABILITY
DESCRIPTION	Special report looks at the regional effects of climate change.
TOOL TYPE	Report
YEAR	1997
FOCUS	Vulnerability to climate change
SCOPE	Regional
REFERENCE/LINK	IPCC (1997). A Special Report of IPCC Working Group II. Published for the Intergovernmental Panel on Climate Change in November 1997.

TOOL 26	CLIMATE AND AGRICULTURE IN THE PACIFIC ISLANDS: FUTURE PERSPECTIVES
DESCRIPTION	Report looking at the vulnerability of agriculture to future climate variability.
TOOL TYPE	Report
YEAR	1993
FOCUS	Climate and agriculture
SCOPE	Pacific region
REFERENCE/LINK	IPS (1993) Edited by Aalbersberg, W. *et al.*, Institute of Pacific Studies (IPS), Suva, FIJI.

TOOL 27	AGROFORESTRY IN TROPICAL ISLANDS
DESCRIPTION	Proceedings of the Technical Meeting on Agroforestry in Tropical Islands.
TOOL TYPE	Meeting proceedings
YEAR	1988
FOCUS	Agroforestry
SCOPE	Pacific region
REFERENCE/LINK	IRETA (1988). Proceedings of the Technical Meeting on Agroforestry in Tropical Islands. Editor. Clements, R. Meeting held in IRETA, USP School of Agriculture, Western Samoa, 23-27 February, 1987. Published by Institute for Research, Extension & Training in Agriculture (IRETA), University for the South Pacific. Alafua Campus, Apia, Samoa.

TOOL 28	CROP CALENDAR SECOND EDITION: A FARMER'S GUIDE TO A BETTER HARVEST
DESCRIPTION	Crop calendar outlining optimal planting and harvesting times for a variety of Pacific crops.
TOOL TYPE	Crop calendar
YEAR	1997
FOCUS	Crop planting and harvesting
SCOPE	Fiji/region
REFERENCE/LINK	MAFF & ALTA (1997). Ministry of Agriculture, Fisheries, Forests and ALTA. Suva Fiji.

TOOL 29	PACIFIC AGROFORESTRY: AN INFORMATION KIT
DESCRIPTION	Comprehensive toolkit for Pacific agroforestry.
TOOL TYPE	Toolkit
YEAR	1999
FOCUS	Agroforestry
SCOPE	Pacific Island countries
REFERENCE/LINK	PRAP (1999). Eds Rogers, S. & Thorpe, P. Publish by the Pacific Regional Agricultural Programme (PRAP), Suva, Fiji Islands. ISBN 982-343-038-1.

TOOL 30	ATOLL AGRICULTURE FOR SECONDARY SCHOOLS. SOILS AND MAJOR AGRICULTURAL CROPS OF MICRONESIA
DESCRIPTION	Useful curriculum resource on crop production and soil resources of Micronesia.
TOOL TYPE	Secondary school course book
YEAR	1983
FOCUS	Agricultural crops
SCOPE	Micronesia
REFERENCE/LINK	Soucie, E.A. (1983). Pats Educational Foundation of Micronesia Inc. Book. 243 pp.

TOOL 31	AGRICULTURE IN THE COOK ISLANDS: NEW DIRECTIONS
DESCRIPTION	Book looking at agricultural systems and production in the Cook Islands.
TOOL TYPE	Book
YEAR	1993
FOCUS	Agriculture
SCOPE	Cook Islands
REFERENCE/LINK	Syed, S. & Mataio, N. (1993). Institute of Pacific Studies (IPS) and the Cook Islands Centre of the University of the South Pacific. Book 152 pages.

TOOL 32	PACIFIC ISLAND AGROBIODIVERSITY AND ETHNOBIODIVERSITY: A FOUNDATION FOR SUSTAINABLE PACIFIC ISLAND LIFE
DESCRIPTION	Paper discussing the importance of agrobiodiversity and ethnobiodiversity for sustainable development in the Pacific region.
TOOL TYPE	Academic paper
YEAR	2008
FOCUS	Agrobiodiversity & ethnobiodiversity
SCOPE	Pacific Island countries
REFERENCE/LINK	Thaman, R.R. (2008). Pacific Island agrobiodiversity and ethnobiodiversity: A foundation for sustainable Pacific Island life. Biodiversity, 9: 1 & 2. 102-110.

TOOL 33	DETERIORATION OF TRADITIONAL FOOD SYSTEMS, INCREASING MALNUTRITION AND FOOD DEPENDENCY IN THE PACIFIC ISLANDS
DESCRIPTION	Paper discussing the deterioration of traditional food systems and its impacts on Pacific Island countries.
TOOL TYPE	Academic paper
YEAR	1982
FOCUS	Traditional food systems
SCOPE	Pacific Island countries
REFERENCE/LINK	Thaman, R.R. (1982). Journal of Food and Nutrition. 39:3, pp 109-121.

TOOL 34	IMPROVEMENT AND DEVELOPMENT OF TRADITIONAL FARMING SYSTEMS FOR THE SOUTH PACIFIC
DESCRIPTION	Workshop proceedings looking at traditional farming systems in Pacific Island countries.
TOOL TYPE	Academic paper
YEAR	2001
FOCUS	Traditional farming systems
SCOPE	Pacific Island countries
REFERENCE/LINK	USP/IRETA (2001). Proceedings of an IRETA workshop. 218-22 October 1999, IRETA, USP Alafua Campus. Published by the Institute for Research, Extension & Training in Agriculture (IRETA).

TOOL 35	CONSENSUS REPORT CLIMATE CHANGE AND BIODIVERSITY IN MELANESIA: WHAT DO WE KNOW?
DESCRIPTION	Report overviews the state of scientific knowledge regarding Melanesia's marine and terrestrial ecosystems and suggests best estimates for the impact that global climate change may have on the region's biodiversity, concluding with a set of recommended guidelines for conservation strategies that are implicit or explicit in the individual reports.
TOOL TYPE	Report
YEAR	2009
FOCUS	Climate change impacts on Melanesian biodiversity
SCOPE	Melanesia
REFERENCE/LINK	Leisz, S., Burnett, B and Allison A. 2009 Bishop Museum http://www2.bishopmuseum.org/ccbm/Areas/Melanesia/Papers

TOOL 36	ASSESSING TSUNAMI DAMAGE TO INDIAN OCEAN MPA'S: EFFORTS UNDERWAY TO FIND ANSWERS AMID CHAOS
DESCRIPTION	Article assesses tsunami damage to mangroves in the Indian Ocean.
TOOL TYPE	Article
YEAR	2005
FOCUS	Mangroves and tsunamis
SCOPE	Indian Ocean
REFERENCE/LINK	MPA News (2005). MPA News 6(7). http://mangroveactionproject.org

TOOL 37	A MULTI-SCALE ASSESSMENT OF HURRICANE IMPACTS ON AGRICULTURAL LANDSCAPES BASED ON LAND USE AND TOPOGRAPHIC FEATURES
DESCRIPTION	Academic paper looking at the impact of hurricanes on agricultural landscapes.
TOOL TYPE	Report
YEAR	2008
FOCUS	Hurricane impacts
SCOPE	Global
REFERENCE/LINK	Philpott *et al.* (2008). Agricultural Systems and Environment – June 2008.

TOOL 38	THE ENVIRONMENTAL FOOD CRISIS – THE ENVIRONMENTS ROLE IN AVERTING FUTURE FOOD CRISIS
DESCRIPTION	Book outlining the environment's role in averting future food crises.
TOOL TYPE	Book
YEAR	2009
FOCUS	Food security
SCOPE	Global
REFERENCE/LINK	http://www.grida.no/publications/rr/food-crisis/ebook.aspx

TOOL 39	MILLENNIUM ECOSYSTEM ASSESSMENT
DESCRIPTION	The Millennium Ecosystem Assessment assessed the consequences of ecosystem change for human wellbeing. From 2001 to 2005, the MA involved the work of more than 1 360 experts worldwide. Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably.
TOOL TYPE	Report
YEAR	2005
FOCUS	Ecosystem change
SCOPE	Global
REFERENCE/LINK	http://www.millenniumassessment.org/en/Index.aspx

TOOL 40	AGRICULTURE, FORESTRY AND CLIMATE CHANGE
DESCRIPTION	Policy brief on agriculture, forestry and climate change in the Pacific.
TOOL TYPE	Policy brief
YEAR	7/2009
FOCUS	Climate change
SCOPE	Pacific Island countries
REFERENCE/LINK	Secretariat for the Pacific Community http://www.spc.int/sppu/images/stories/policy%20brief_7.pdf

TOOL 41	TECHNOLOGY FOR AGRICULTURE (TECA)
DESCRIPTION	TECA is an FAO initiative to improve access to information and knowledge about available proven technologies in order to enhance their adoption in agriculture, livestock, fisheries and forestry and thus contribute to food security, poverty alleviation and sustainable development.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Developing nations
SCOPE	Developing nations
REFERENCE/LINK	http://www.fao.org/teca

TOOL 42	PACIFIC AGRICULTURAL TRADERS HANDBOOK (PATH)
DESCRIPTION	PATH is an online tool developed to facilitate agricultural exports from the Pacific Islands to New Zealand. PATH provides a wealth of information for Pacific exporters, including New Zealand market reports, advice from New Zealand importers on achieving maximum growth and profit as well as market insights for Pacific growers and exporters of produce including taro, ginger, vanilla, papayas, mangoes and more.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Developing nations
SCOPE	Developing nations
REFERENCE/LINK	http://www.path2nz.com

TOOL 43	IFOAM WEB SITE
DESCRIPTION	Comprehensive searchable Web site for the International Federation of Organic Agriculture Movements (IFOAM). It is a grassroots and democratic organization that currently unites 750 member organizations in 108 countries.
TOOL TYPE	Web site
YEAR	2009
FOCUS	Organic farming
SCOPE	Global
REFERENCE/LINK	http://www.ifoam.org

TOOL 44	SOUTH PACIFIC FOOD LEAFLETS 1 TO 18
DESCRIPTION	Leaflets on various key food crops in the Pacific.
TOOL TYPE	Information sheets
YEAR	1980
FOCUS	Food preparation and nutrition
SCOPE	Pacific region
REFERENCE/LINKS	Published by the South Pacific Commission http://www.fao.org/Wairdocs/X5425E/X5425E00.htm#Contents

TOOL 45	TRADITIONAL DISASTER REDUCTION IN PACIFIC ISLAND COMMUNITIES
DESCRIPTION	Report looking at traditional disaster risk reduction strategies used by Pacific Island countries.
TOOL TYPE	Report
YEAR	2006
FOCUS	Disaster risk reduction
SCOPE	Pacific Island countries
REFERENCE/LINK	Authored by Campbell, J. R., GNS Science Report 2006/38 46 p http://www.gns.cri.nz/services/hazardsplanning/downloads/SR2006-038trad_mitigation_pacific.pdf

TOOL 46	THE AgNIC TRADITIONAL PACIFIC ISLAND CROPS WEB SITE
DESCRIPTION	The AgNIC Traditional Pacific Island Crops pages are the University of Hawaii at Manoa Library's contribution to the Agriculture Network Information Center (AgNIC) project coordinated by the National Agricultural Library, USDA. The goal is to provide links to quality World Wide Web resources that deal with the production, marketing and research aspects of 12 important traditional Pacific Island crops. Related marketing and statistical sites, databases, and other reference sources are also included.
TOOL TYPE	Web site
YEAR	2010
FOCUS	Pacific agriculture
SCOPE	Pacific Island countries
REFERENCE/LINK	http://libweb.hawaii.edu/libdept/scitech/agnic/index.html

INVASIVE SPECIES TOOLS

TOOL 47	GUIDELINES FOR INVASIVE SPECIES MANAGEMENT IN THE PACIFIC
DESCRIPTION	A Pacific strategy for managing pests, weeds and other invasive species.
TOOL TYPE	Guidebook
YEAR	2009
FOCUS	Invasive species
SCOPE	Pacific region
REFERENCE/LINK	Guidelines for invasive species management in the Pacific: a Pacific strategy for managing pests, weeds and other invasive species / compiled by Alan Tye – Apia Samoa: SPREP 2009, 20 p. ISBN 978-982-04-0388-8

TOOL 48	PACIFIC INVASIVES LEARNING NETWORK (PILN)
DESCRIPTION	Multi-partner peer learning network aimed at combating the invasive species in the Pacific region.
TOOL TYPE	Peer learning network
YEAR	2 year pilot launched in 2006
FOCUS	Invasive species
SCOPE	Pacific region
REFERENCE/LINK	www.sprep.org/piln/ Email: piln@sprep.org

FISHERIES & MARINE ECOSYSTEMS TOOLS

TOOL 49	PRELIMINARY ASSESSMENT OF THE EFFECTS OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE IN THE PACIFIC
DESCRIPTION	Brief report that outlines how the climate of the Pacific is projected to change, how climate change has affected fisheries elsewhere in the world, and how it is expected to affect fisheries and aquaculture in the Pacific. The emphasis is on the implications for economies PICTs.
TOOL TYPE	Appendix 4 to report by the Asian Development Bank “Fisheries in the Economies of the Pacific Island Countries and Territories”.
YEAR	2009
FOCUS	Fisheries and climate change adaptation
SCOPE	PICTs
REFERENCES	http://www.spc.int/sppu/images/stories/preliminary%20assessment.pdf

TOOL 50	PLANNING THE USE OF FISH FOR FOOD SECURITY IN THE PACIFIC
DESCRIPTION	Paper outlining the role of fisheries resources for Pacific food security.
TOOL TYPE	Academic policy paper
YEAR	2009
FOCUS	Food security and Pacific fisheries
SCOPE	PICTs
REFERENCES	Authored by Bell *et al.* Marine Policy 22 (2009). 64-69

TOOL 51	THE PACIFIC PLAN
DESCRIPTION	The Pacific Plan was endorsed by Forum Leaders at the Pacific Islands Forum meeting in Port Moresby, October 2005. As a "living document", it now forms the basis of ongoing strengthening of regional cooperation and integration efforts for the benefit of the people of the Pacific.
TOOL TYPE	Regional strategy
YEAR	2007
FOCUS	Pacific development and collaboration
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.forumsec.org.fj/pages.cfm/about-us/the-pacific-plan

TOOL 52	THE VAVA'U DECLARATION ON PACIFIC FISHERIES RESOURCES
DESCRIPTION	High-level declaration on the challenges and issues for Pacific fisheries.
TOOL TYPE	Pacific leaders' declaration
YEAR	2007
FOCUS	Pacific fisheries
SCOPE	PICTs
REFERENCE/LINK	http://www.forumsec.org.fj

TOOL 53	FISH AND FOOD SECURITY – POLICY BRIEF 1/2008
DESCRIPTION	Policy brief on the role fish plays in food security in Pacific Island countries.
TOOL TYPE	Policy brief
YEAR	2008
FOCUS	Fish and food security
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.spc.int

TOOL 54	FISHERIES IN THE ECONOMIES OF THE PACIFIC ISLAND COUNTRIES AND TERRITORIES
DESCRIPTION	This report updates and expands on the 2001 report: "The Contribution of Fisheries to the Economies of Pacific Island Countries". The focus of that publication was the contribution of fishing to gross domestic product (GDP) and it provided an independent estimate of that contribution. In the present report, the scope is expanded to include Pacific Island territories, aquaculture and freshwater fisheries, and some important factors likely to affect the flow of benefits from fisheries in the future.
TOOL TYPE	Report
YEAR	2009
FOCUS	The economics of fishing in PICTs
SCOPE	Pacific region
REFERENCE/LINK	http://www.adb.org/documents/studies/pacific-fisheries/default.asp

TOOL 55	A SHORT HISTORY OF INDUSTRIAL FISHING IN THE PACIFIC ISLANDS
DESCRIPTION	This document presents a summary and review of the development of industrial fisheries in the Pacific Islands. RAP PUBLICATION 2007/22.
TOOL TYPE	Booklet
YEAR	2007
FOCUS	Commercial fishing in the Pacific
SCOPE	Pacific region
REFERENCE/LINK	ftp://ftp.fao.org/docrep/fao/010/ai001e/ai001e00.pdf Email: FAO-RAP@fao.org

TOOL 56	FISHERIES AND CLIMATE CHANGE
DESCRIPTION	Preliminary policy brief on fisheries and climate change in the Pacific.
TOOL TYPE	Policy brief
YEAR	2008
FOCUS	Climate change and fisheries
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.spc.int

TOOL 57	FAO FISHERIES WEB SITE
DESCRIPTION	Comprehensive Web site linking many resources, policies and reports related to global fisheries.
TOOL TYPE	Web site
YEAR	2010
FOCUS	Multiple
SCOPE	Global
REFERENCE/LINK	http://www.fao.org/fishery/ccrf/en

TOOL 58	PIMRIS PORTAL
DESCRIPTION	The PIMRIS Portal is described as a one-stop Web site for all Pacific marine fisheries information.
TOOL TYPE	Web site
YEAR	2010
FOCUS	Marine fisheries
SCOPE	Pacific Island countries
REFERENCE/LINK	http://www.pimrisportal.org

TOOL 59	BUILDING ADAPTIVE CAPACITY TO CLIMATE CHANGE: POLICIES TO SUSTAIN LIVELIHOODS AND FISHERIES
DESCRIPTION	A policy brief series on building the adaptive capacity of fisheries to climate change.
TOOL TYPE	Policy briefs
YEAR	2007
FOCUS	Fisheries and livelihoods
SCOPE	Global
REFERENCE/LINK	New Directions in Fisheries, a series of policy briefs on development issues. Number 8 http://www.sflp.org/briefs/eng/policybriefs.html

TOOL 60	FAO FISHERIES AND AQUACULTURE – A MISSION FOR GLOBAL RESPONSIBLE DEVELOPMENT AND USE OF FISHERIES AND AQUACULTURE
DESCRIPTION	This booklet provides a global overview of role of fisheries and aquaculture in food security, livelihoods and trade.
TOOL TYPE	Booklet
YEAR	2007
FOCUS	Fisheries
SCOPE	Global
REFERENCE/LINK	ftp://ftp.fao.org/FI/brochure/Fisheries.../2007/a1014e.pdf

AQUACULTURE

TOOL 61	THE ECOSYSTEM APPROACH TO COASTAL FISHERIES AND AQUACULTURE IN PACIFIC ISLAND COUNTRIES AND TERRITORIES
DESCRIPTION	This booklet, authored by Gary Preston, presents key information on aspects of the "Ecosystem Approach to Coastal Fisheries and Aquaculture", based on a study carried out by the Secretariat of the Pacific Community (SPC) and The Nature Conservancy (TNC).
TOOL TYPE	Booklet
YEAR	2009
FOCUS	Ecosystem-based approach to Pacific fisheries in Pacific Island countries and territories
SCOPE	Sustainability and adaptation
REFERENCE/LINK	http://conserveonline.org/ Email: PublicationsSection@spc.int

TOOL 62	FISHERIES AND AQUACULTURE IN OUR CHANGING CLIMATE
DESCRIPTION	Policy brief prepared by PaCFA, which is a voluntary global-level initiative among 18 international organizations and sector bodies with a common concern for climate change interactions with global waters, living resources and their social and economic consequences.
TOOL TYPE	Policy brief
YEAR	2009
FOCUS	Climate change and fisheries
SCOPE	Global
REFERENCE/LINK	ftp://ftp.fao.org/FI/PaCFA/PressRelease_dec_09.pdf

TOOL 63	SPC AQUACULTURE PORTAL
DESCRIPTION	Web site provides a forum dedicated to promoting a regional framework for sustainable aquaculture, in the areas of planning, research, development and trade, for Pacific Island governments, private enterprises and other stakeholders.
TOOL TYPE	Web site
YEAR	2010
FOCUS	Aquaculture
SCOPE	Pacific Island countries
REFERENCE/LINK	https://spc.int/aquaculture/index.php?limitstart=10

TOOL 64	A REVIEW OF AQUACULTURE IN THE PACIFIC ISLANDS 1998-2007
DESCRIPTION	A review of aquaculture in the Pacific carried out by the Secretariat of the Pacific Community (SPC) on behalf of its 22 Pacific Island member countries. Authored by Ben Ponia, it establishes that aquaculture has an important role in diversifying trade, increasing capacity for fisheries production, and contributing to rural development in the Pacific.
TOOL TYPE	Review
YEAR	2010
FOCUS	Aquaculture review, statistics, production volumes, aquaculture values
SCOPE	Pacific region
REFERENCE/LINK	http://www.spc.int/aquaculture

TOOL 65	AQUACULTURE ACTION PLAN 2007 (SECRETARIAT OF THE PACIFIC COMMUNITY, SPC)
DESCRIPTION	The SPC Aquaculture Action Plan 2006 is a vehicle for taking SPC members and partners one step closer to fulfilling the potential of aquaculture in the region. It outlines the importance of aquaculture to the Pacific, the sector as it is today, the commodities that will carry it forward, and the actions required to get there.
TOOL TYPE	Action plan
YEAR	2006/2007
FOCUS	Aquaculture Oceania, coastal fisheries
SCOPE	Pacific region
REFERENCE/LINK	http://www.spc.int/aquaculture

CORAL REEFS

TOOL 66	FROM MANGROVES TO CORAL REEFS
DESCRIPTION	Handbook, authored by Micheal King, about marine and coastal ecosystems in the Pacific Islands region.
TOOL TYPE	Handbook
YEAR	2004
FOCUS	Marine ecosystems in the Pacific Islands
SCOPE	Pacific Island countries
REFERENCES	www.sprep.org.ws. Published by SPREP, Apia, SAMOA.

TOOL 67	CORAL REEFS AND GLOBAL CLIMATE CHANGE: POTENTIAL CONTRIBUTIONS OF CLIMATE CHANGE TO STRESSES ON CORAL REEF ECOSYSTEMS
DESCRIPTION	An academic paper focusing on climate change and coral reefs.
TOOL TYPE	Academic paper
YEAR	2004
FOCUS	Coral reefs
SCOPE	Global
REFERENCE/LINK	Buddemeier, R.W., J.A. Kleypas, R.B. Aronson. (2004). Prepared for the Pew Center of Global Climate Change.

TOOL 68	CONSERVING MELANESIA'S CORAL REEF HERITAGE IN THE FACE OF CLIMATE CHANGE
DESCRIPTION	An academic paper looking at the pending impact of climate change on coral reefs in Melanesia.
TOOL TYPE	Academic paper
YEAR	2008
FOCUS	Coral reefs and climate change
SCOPE	Melanesia
REFERENCE/LINK	Foale, S.J. (2008). Historic Environment. Vol. 21:1.

TOOL 69	CORAL REEF RESILIENCE & RESISTANCE TO BLEACHING
DESCRIPTION	A Global marine programme working paper looking at the relationship between climate change, coral bleaching and coral reef degradation.
TOOL TYPE	Working paper
YEAR	2005
FOCUS	Coral reef resilience
SCOPE	Global
REFERENCE/LINK	Grimsditech, G.D., Selm, S.V. (2005). IUCN, Gland, Switzerland, 50 pp.

TOOL 70	IN THE FRONTLINE: SHORELINE PROTECTION AND OTHER ECOSYSTEM SERVICES FROM MANGROVES AND CORAL REEFS
DESCRIPTION	A report looking at the role of mangroves and coral reefs in protecting shorelines.
TOOL TYPE	Report
YEAR	2006
FOCUS	Ecosystem services of mangroves and coral reefs
SCOPE	Global
REFERENCE/LINK	Wells, S., C. Ravilious, E. Corcoran. (2006). UNEP World Conservation Monitoring Centre.

TOOL 71	CORAL REEFS & CLIMATE CHANGE
DESCRIPTION	Two-page factsheet outlining the impact of climate change on Pacific coral reefs.
TOOL TYPE	Factsheet
YEAR	2009
FOCUS	Climate change and Pacific coral reefs
SCOPE	Pacific Island countries
REFERENCE/LINK	SPREP Factsheet No. PYCC-002. Email: sprep@sprep.org. http://www.sprep.org/factsheets

TOOL 72	CLIMATE CHANGE AND THE FUTURE OF CORAL REEF FISHES
DESCRIPTION	A paper investigating how climate change will impact coral reef fishes through effects on individual performance, trophic linkages, recruitment dynamics, population connectivity and other ecosystem processes.
TOOL TYPE	Academic paper
YEAR	2007
FOCUS	Climate change and coral reef fishes
SCOPE	Global
REFERENCE/LINK	Munday *et al.* (2008). Fish and Fisheries Vol. 9, pp. 261-285.

TOOL 73	CORAL REEFS UNDER RAPID CLIMATE CHANGE AND OCEAN ACIDIFICATION
DESCRIPTION	This review presents future scenarios for coral reefs that predict increasingly serious consequences for reef-associated fisheries, tourism, coastal protection and people.
TOOL TYPE	Academic paper
YEAR	2008
FOCUS	Climate change and ocean acidification
SCOPE	Global
REFERENCE/LINK	Hoegh-Guldberg *et al.* (2007). Science Vol. 318, pp. 1737- 1742.

TOOL 74	COASTS OF PACIFIC ISLANDS
DESCRIPTION	This booklet provides information on the coasts of Pacific Island countries.
TOOL TYPE	Booklet
YEAR	1996
FOCUS	Pacific coasts
SCOPE	Pacific Island countries
REFERENCE/LINK	SOPAC Miscellaneous Report 222

MANGROVES

TOOL 75	MANGROVES IN A CHANGING CLIMATE AND RISING SEA
DESCRIPTION	Report on impact of climate change on mangrove ecosystems in the Pacific. This publication was prepared by UNEP in cooperation with the Secretariat of the Pacific Regional Environment Programme (SPREP) and Western Pacific Regional Fishery Management Council (WPRFMC). UNEP and WPRFMC provided financial support for the research on which the content of this publication is based.
TOOL TYPE	Report
YEAR	2006
FOCUS	Mangroves
SCOPE	Pacific
REFERENCE/LINK	Gilman, E. *et al.* (2006). Pacific Island Mangroves in a Changing Climate and Rising Sea. UNEP Regional Seas Reports and Studies No. 179. United Nations Environment Programme, Regional Seas Programme, Nairobi, Kenya. www.unep.org

TOOL 76	PROCEEDINGS OF THE PACIFIC REGIONAL WORKSHOP ON MANGROVE WETLAND PROTECTION AND SUSTAINABLE USE
DESCRIPTION	Proceedings of Pacific Regional Workshop looking at the sustainable use and protection of mangroves and wetlands (held in Suva, Fiji, 12-16 June 2001).
TOOL TYPE	Conference proceeding
YEAR	2002
FOCUS	Mangroves and wetlands
SCOPE	Pacific region
REFERENCE/LINK	Published by SPREP. Email: sprep@sprep.org

TOOL 77	THREATS TO MANGROVES FROM CLIMATE CHANGE AND ADAPTATION OPTIONS
DESCRIPTION	Academic paper focusing on the impacts of climate change on mangroves and appropriate adaptation measures.
TOOL TYPE	Academic paper
YEAR	December 2007.
FOCUS	Mangroves and climate change adaptation
SCOPE	Global
REFERENCE/LINK	Gilman *et al.* (2007), Aquatic Botany

TOOL 78	MANGROVE ACTION PROJECT
DESCRIPTION	The Mangrove Action Project is dedicated to reversing the degradation and loss of mangrove forest ecosystems worldwide. Its main goal is to promote the rights of traditional and indigenous coastal peoples, including fishers and farmers, to manage their coastal environs sustainably.
TOOL TYPE	Project and Web site
YEAR	2000
FOCUS	Mangrove restoration
SCOPE	Global
REFERENCE/LINK	http://mangroveactionproject.org

TOOL 79	VALUING MANGROVE CONSERVATION IN SOUTHERN THAILAND
DESCRIPTION	Academic paper investigating the economic valuation of mangroves.
TOOL TYPE	Academic paper
YEAR	2001
FOCUS	Mangrove conservation
SCOPE	Southern Thailand
REFERENCE/LINK	Suthawan & Barbier (2001). *Contemporary Economic Policy* Vol. 19, No.2: 109–122.

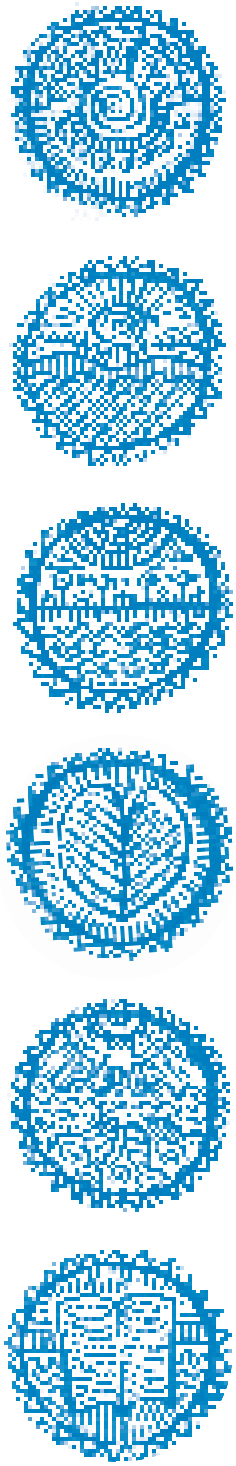
SEAGRASSES TOOLS

TOOL 80	ACCELERATING LOSS OF SEAGRASSES ACROSS THE GLOBE THREATENS GLOBAL ECOSYSTEMS
DESCRIPTION	Academic paper outlining the role of and the global loss of seagrass ecosystems.
TOOL TYPE	Academic paper
YEAR	2009
FOCUS	Seagrasses
SCOPE	Global
REFERENCE/LINK	Waycott *et al.* (2009). PNAS Early Edition – May 2009.

TOOL 81	THE FUTURE OF SEAGRASS MEADOWS
DESCRIPTION	Academic paper looking at the future sustainability of seagrass meadows.
TOOL TYPE	Academic paper
YEAR	2002
FOCUS	Seagrass and climate change
SCOPE	Global
REFERENCE/LINK	Duarte, C (2002). Environmental Conservation 29 (2) pp192-206.

TOOL 82	A GLOBAL CRISIS FOR SEAGRASS ECOSYSTEMS
DESCRIPTION	Overview of seagrass ecosystems and future environmental impacts.
TOOL TYPE	Academic paper
YEAR	2006
FOCUS	Seagrass ecosystems
SCOPE	Global
REFERENCE/LINK	Orth, R.J. *et al.* (2006) Bioscience – December 2006/Vol 56 No. 12.

TOOL 83	RECOGNIZING THE NECESSITY FOR INDO-PACIFIC SEA GRASS CONSERVATION
DESCRIPTION	Paper focusing on the need for the conservation of seagrass in the Indo-Pacific region.
TOOL TYPE	Academic paper
YEAR	2010
FOCUS	Seagrass conservation
SCOPE	Indo-Pacific
REFERENCE/LINK	Unsworth, R.K.F. & Cullen, L.C. (2010). Conservation Letters 00:1-11.



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