5. Investments required

To maintain the important contributions of fisheries and aquaculture to economic development, government revenue, food security and livelihoods, PICTs and their development partners will need to make investments at several levels. In particular, investments are needed to:

1. launch the win-win and lose-win adaptations to address the threats and opportunities associated with climate change and other drivers (Section 3);
2. fill the gaps in knowledge required to improve our understanding of vulnerability (Section 4);
3. strengthen the partnerships needed to implement adaptations effectively and fill the gaps in knowledge; and
4. monitor the projected effects of climate change on fisheries and aquaculture, and the success of adaptations {Chapter 13, Section 13.7}.

5.1 Investments to implement adaptations

The adaptations recommended in Section 3 to reduce the threats posed by climate change to contributions by fisheries and aquaculture to Pacific communities, and to capitalise on the opportunities, will require the following investments.

5.1.1 Economic development and government revenue

- Full implementation of the vessel day scheme for the purse-seine and the longline fisheries by all PNA members, together with similar management arrangements to limit fishing effort for tuna in subtropical waters by the members of the Te Vaka Moana Arrangement.
- Development of a long-term economic partnership agreement (EPA) with the EU by PNG, Fiji and Solomon Islands to help secure future supplies of tuna for their canneries.
- Establishment of (1) competent authorities for fishery product food safety and the associated testing laboratories or services, and (2) systems for demonstrating compliance with IUU fishing regulations in PICTs well placed to supply canneries in those countries which have EPAs with the EU.
- Energy audits and energy efficiency programmes for national industrial tuna fleets to assist them to cope with fluctuations in oil prices, and reduce the costs of fishing further afield as the distribution of tuna shifts to the east.
- Safety audits for purse-seine and longline vessels.

- Production chain accounting of all emissions from tuna fishing and canning/processing operations, and transport to markets, for carbon labelling of tuna products from the region.
- Training of women for managerial roles in tuna canneries and loining plants.

5.1.2 Food security and livelihoods

- Integrated land use planning to stabilise soils and prevent high sediment loads from entering streams and reaching the coast, including (1) revegetation of areas in catchments most likely to intercept sediment, and (2) establishing well-vegetated riparian (stream side) buffer zones. Revegetation will not only reduce the vulnerability of fish habitats {Chapters 5–7}, it will help mitigate CO_2 emissions by boosting carbon sequestration. Pacific leaders identified solutions to deforestation and forest degradation as a key response to climate change in their 'Call to Action on Climate Change' in 2009[ii].
- Cross-sectoral cooperation in the development of national adaptation programmes of action (NAPAs) to (1) integrate the protection and management of coral reef, mangrove, seagrass and intertidal flat fish habitats, and freshwater and estuarine fish habitats, with other plans to assist all sectors adapt to climate change; and (2) identify the modifications to infrastructure needed to allow mangroves and other coastal fish habitats to migrate landward as sea level rises.
- Capacity-building of fisheries agencies and management advisory groups in all PICTs to guide communities in (1) implementing CEAFM, incorporating primary fisheries management and ecosystem-based approaches to management of coastal and freshwater fish habitats and stocks {Chapter 13}, and (2) assessing the implications of climate change and the cost and effectiveness of potential adaptation options.
- Practical business models, and incentives, for the private sector to engage in storage, processing and distribution of low-cost tuna and bycatch landed at major ports, to provide increased access to fish for rapidly growing urban populations.
- Cost:benefit analysis of producing canned tuna for local and export markets.
- Assessment of the feasibility and practicality of using a portion of licence fees from DWFNs to offset the cost of locally-canned tuna for inland populations in PNG.
- Surveys to identify the best sites for installing inshore FADs to increase access to tuna for subsistence and small-scale commercial fishers in rural areas, followed by programmes to install and maintain FADs at these sites as part of the national infrastructure for food security. This will involve maintaining stockpiles of equipment at national fisheries agencies to replace FADs as required.

ii Pacific Islands Forum Secretariat, Forum Communiques; www.forumsec.org.fj/pages.cfm/documents/forum-communiques

- Analysis to identify the prime locations for peri-urban and rural pond aquaculture based on information on rainfall and temperature from downscaled global climate models, and other demographic and natural resources layers available for GIS.
- National and private-sector hatcheries to produce juvenile fish for pond aquaculture, supported by distribution networks to deliver high-quality juveniles to rural areas.
- Evaluation of the potential merits of micro-credit schemes and training programmes to enable coastal communities to (1) develop small-scale commercial fisheries around FADs and for small pelagic fish species; (2) expand pond aquaculture; and (3) scale-up post-harvest processing, where credit is recognised as a barrier to implementing these adaptations.
- Training and capacity building for coastal communities, especially women, to engage in (1) income-earning opportunities created by diversifying food production systems (in fisheries, aquaculture and agriculture) to build resilience to climate change; and (2) operate small businesses.
- Analysis of carbon footprints of the main aquaculture operations, and identification of better ways to conserve energy along the supply chain. Such investments should also consider innovative strategies to market environmentally-friendly products based on better management of natural resources.

5.1.3 Increasing participation and awareness

- Research to identify the key social mechanisms and drivers that influence participation by men, women and youth in the planning, design and implementation of adaptations to climate change.
- Educational materials to assist communities to understand (1) the contributions of fisheries and aquaculture to food security and livelihoods; (2) the fundamentals of climate change; (3) the timing of the projected effects of climate change on fisheries and aquaculture, and (4) the need to manage catchments and freshwater and coastal fish habitats well to improve the resilience of fish stocks to climate change.
- Interactive and educational computer games for children to (1) promote learning (by having fun) about vulnerability of fisheries and aquaculture (and other sectors) to climate change; (2) help them understand the consequences of adapting or not adapting; and (3) allow them to recognise other disaster risk management choices and outcomes.

5.2 Investments to fill gaps in knowledge

The information set out in Chapters 2–12 describes our current understanding of the natural and social processes underpinning the contributions of fisheries and aquaculture to the well-being of Pacific communities, and how these processes are

likely to be affected by climate change. This knowledge is far from complete. The investments needed to improve and regularly update this vulnerability assessment are summarised below.

5.2.1 Surface climate and the tropical Pacific Ocean

- Building the capacity of PICTs to (1) forecast the weather and make short-term seasonal climate predictions, particularly for tropical cyclones and ENSO events; and (2) operate appropriate warning systems for severe weather events and other potential natural catastrophes (earthquakes and tsunamis).
- Constructing additional weather stations throughout the region to make long-term, high-quality surface weather observations, to assist PICTs to (1) detect the nature and significance of changing climates; (2) link relevant island-scale weather patterns to larger-scale climate observations; and (3) relate changes in rainfall to variations in local river flows and groundwater regimes.
- Developing higher-resolution physical global climate models that (1) address existing biases in the position of the South Pacific Convergence Zone and the spatial and temporal structure of ENSO, and (2) are capable of projecting changes to the frequency and intensity of ENSO events and tropical cyclones. These downscaled models are needed to provide a better understanding of the likely changes to the surface area and structure of the Warm Pool and PEQD, which are of great significance to the distribution and abundance of tuna.

5.2.2 Oceanic fisheries

- Expansion of the SEAPODYM model used to estimate tuna catches under different climate change scenarios to (1) link higher-resolution, physical global climate models to better biogeochemical models (see below); and (2) incorporate socio-economic scenarios likely to drive future fishing effort in the region (e.g. increasing demand for tuna from industry and from PICTs for food security, demographic changes, projected spatial changes in fishing effort, and increasing fuel costs).
- Development, parameterisation and verification of biogeochemical models, including collection of data on variability of nutrients, oxygen, pH, phytoplankton, zooplankton and micronekton throughout the water column; movements of tuna; diets of juvenile and adult tuna; and the responses of juvenile tuna to ocean acidification. This involves:
  - obtaining catch data from vessel logbooks reporting the exact locations where fish were caught in the tropical Pacific Ocean;
  - establishing long-term monitoring stations for physical and chemical variables in all provinces;

- adding biochemical and acoustic sensors to the Tropical Atmosphere Ocean (TAO) array of moorings in the Warm Pool and PEQD, and/or to the Argo floats[iii];
- continuing the satellite remote sensing of SST and chlorophyll *a*, so that changes in the convergence zone between the Warm Pool and PEQD can be tracked easily;
- validating the accuracy of acoustic data in discerning the relative abundance of the main groups of micronekton, so that 'ships of opportunity' fitted with suitable instrumentation can build up time-series of variation in micronekton along major shipping routes[iv];
- supporting observers on industrial tuna vessels to sample micronekton from the stomachs of tuna and other top predators;
- tagging programmes for all four species of tuna, both with conventional and electronic tags, to verify projected changes in their distributions in response to altered nutrients, water temperatures, currents and oxygen levels, including movements in archipelagic waters; and
- assessing the effects of ocean acidification on recruitment success of tuna larvae.

➢ Regular assessments of the projected catches of all four species of tuna under selected climate change scenarios every 5–7 years, using the enhanced SEAPODYM model {Chapter 8}, to inform regional and national management agencies.

5.2.3 Coastal fisheries

➢ Sampling programmes to determine how (1) spatial and temporal variation in environmental stressors, such as SST, affect the three-dimensional architecture of the coral reefs that support demersal fish {Chapter 9}, and (2) coral reefs respond to appropriate management measures to prevent degradation.

➢ Modification of the available satellite products to (1) provide the finer-scale measurements (< 1 km grid size) needed to manage individual reefs; and (2) integrate data on light intensity, pH and turbidity with SST.

➢ Maps of mangroves, seagrasses and intertidal flats for all PICTs to help (1) quantify the contribution of these habitats to coastal fisheries production; (2) raise awareness among coastal planners of their importance; and (3) provide a baseline for monitoring changes in the area, density and species composition of mangroves and seagrasses, and the area of intertidal flats.

iii www.argo.ucsd.edu

iv See www.imber.info/CLIOTOP_MAAS.html for more details.

- Continued collection of reliable data on sea-level rise in PICTs through the South Pacific Sea Level and Climate Change Monitoring Project.
- Higher-resolution topographic maps to identify more accurately (1) the projected losses of mangroves and intertidal flats blocked from migrating landward by infrastructure; and (2) the areas likely to be inundated that have potential for colonisation by mangroves and seagrasses.
- Surveys of the biodiversity, relative abundance and size composition of fauna associated with coral reefs, mangroves, seagrasses and intertidal flats at representative locations to improve our understanding of the food webs for coastal fisheries supported by these habitats.
- Research on key fish and invertebrate species harvested by coastal fisheries to determine:
  - how their distributions and abundances are linked to the coral reef, mangrove, seagrass and intertidal flat habitats that support them, and how these relationships are likely to change as these habitats are degraded {Chapters 5 and 6};
  - the likely effects of increases in SST and ocean acidification, and changes in the strength of major ocean currents, on successful recruitment of fish to coastal habitats;
  - whether the incidence and virulence of ciguatera fish poisoning is likely to vary as SST increases, and as coral cover decreases and macroalgae increase; and
  - the possible effects of increased runoff from high islands on the abundance of small pelagic fish species.

5.2.4 Freshwater and estuarine fisheries

- Higher-resolution elevation maps and flood modelling to identify likely changes to floodplain and estuarine fish habitats. This information will allow national planners to provide for increased fisheries production when developing cross-sectoral strategies to adapt to projected increases in rainfall and sea-level rise.
- Development of fisheries production models for the Fly and Sepik-Ramu rivers in PNG, based on (1) inventories of freshwater habitats and elevation mapping; (2) better data for catch and fishing effort, especially for subsistence fisheries; and (3) improved projections of flow rates, nutrient loads, water temperature and dissolved oxygen from downscaled global climate models.

5.2.5 Aquaculture

- Impact risk assessments for the introduction or further translocation of Nile tilapia for pond aquaculture. These assessments should provide decision-makers with science-based advice about any possible effects on freshwater biodiversity,

ensuring that any such potential effects are not confounded with habitat degradation, and are relative to any existing impacts on biodiversity that can be attributed unequivocally to Mozambique tilapia.

- Assessments of how long existing shrimp ponds are likely to function efficiently, followed by modifications to, or relocation of, ponds when required to ensure that they can be dried completely between crops as sea level rises {Chapter 11}.
- Research to determine the likely effects of ocean acidification on growth and survival of juvenile and adult pearl oysters, and pearl quality. In the event of projected deleterious effects, investments should be made to identify micro-sites that may retain adequate aragonite saturation levels due to buffering by nearby reefs and seagrasses to support continued farming of pearls and other commodities likely to be affected by ocean acidification (e.g. corals and giant clams for the ornamental trade).

5.3 Investments to strengthen partnerships

Because many PICTs have limited national technical capacity, investments are needed to develop the technical and scientific teams required to assist PICTs to (1) implement and refine the key adaptations described in Section 3; (2) improve their understanding of the vulnerability of fish habitats, fish stocks, and the enterprises and communities depending on these resources; and (3) fill the remaining gaps in knowledge.

In the case of coastal fisheries, this will involve providing continued support to the scientific institutions, regional organisations and non-governmental organisations (NGOs) already assisting PICTs to implement CEAFM. For oceanic fisheries, partnerships are needed to provide research teams with better access to Pacific basin-wide fishing data sets, i.e. combined databases from WCPFC and IATTC, as the distributions of skipjack, yellowfin and bigeye tuna move progressively east.

Support for the continued development of the Global Partnership for Climate, Fisheries and Aquaculture (PaCFA)[v] should also be considered to ensure that lessons learned from other regions can be passed on to PICTs, and vice versa.

5.4 Investments to monitor changes in resources and the success of adaptations

Investments in a variety of monitoring programmes are required to assist PICTs to improve their understanding of the status of natural resources, assess whether the projected effects of climate change on these resources are occurring, and measure the success of adaptations. The specific investments needed are outlined below.

v www.climatefish.org

- Development of a digital image analysis system to record changes in species composition and size-frequency of tuna caught by purse-seine vessels, where data can preferably be processed by computers on board and transmitted to the Forum Fisheries Agency and Secretariat of the Pacific Community via the vessel monitoring system.
- Regular mapping of vegetation cover in catchments to monitor the success of revegetation programmes.
- Long-term monitoring programmes to (1) inform PICTs about changes in coastal fish habitats and stocks of demersal fish (including market sampling); (2) determine the variation in habitats and stocks due to climate change, as opposed to other drivers; and (3) assess whether the effects of climate change are occurring as projected.
- Modifications to household income and expenditures surveys and censuses to measure the success of adaptations (against socio-economic baselines) in maintaining the contributions of fisheries and aquaculture to food security and livelihoods.

5.5 Investments to localise the vulnerability assessment

The results of this assessment need to be transferred to the local level by supporting NGOs and other agencies to assist communities to make semi-quantitative evaluations of their vulnerability {Chapters 2–12}. Such semi-quantitative evaluations involve applying regional and local knowledge at a community level to identify and understand the specific sources of vulnerability, and how these can be minimised. This approach allows integration across sectors and scales to produce effective adaptation plans. It also builds capacity within communities to implement adaptations.