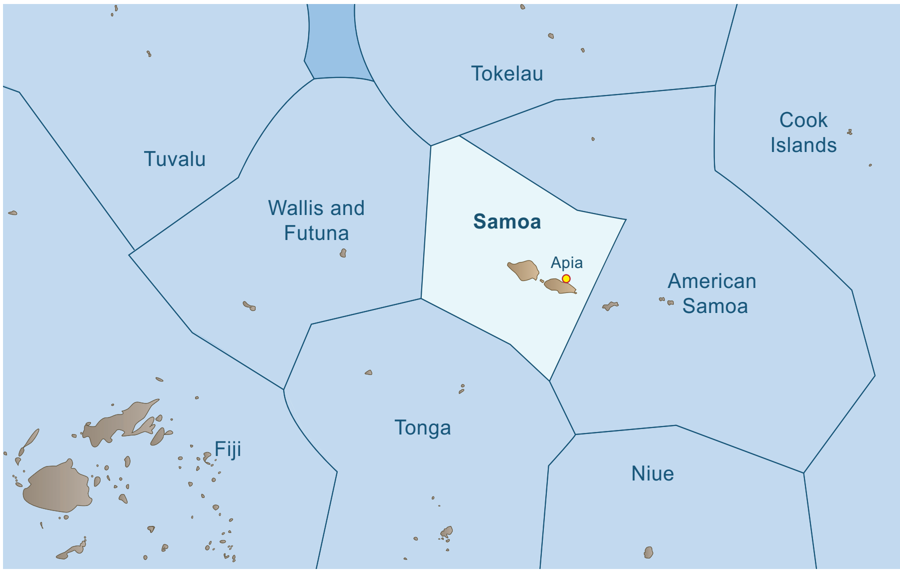
2.16 Samoa



Key features

Population

Year	2010	2035	2050	2100
Population (x 1000)[a]	183	202	210	240
Population growth rate[a]	0.3	0.3	0.3	0.4

a = Data from SPC Statistics for Development Programme (www.spc.int/sdp).

EEZ area (km²) 110,365

Land area (km²) 2935

Land as % of EEZ 2.6

Fisheries and aquaculture activities: Oceanic fisheries, coastal fisheries, freshwater and estuarine fisheries and coastal and pond aquaculture.

Membership of regional fisheries management arrangements: Forum Fisheries Agency; Western and Central Pacific Fisheries Commission; Te Vaka Moana Arrangement; South Pacific Tuna and Billfish subcommittee.

Surface climate and the ocean

Existing features

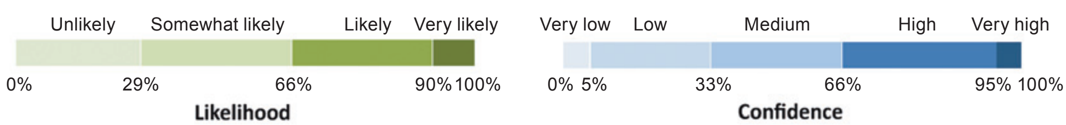
Samoa has a tropical climate {Chapter 2}. Recent air temperatures in Apia have averaged 27.0°C and average rainfall is > 2800 mm per year. Samoa lies within the South Pacific Subtropical Gyre Province (SPSG) {Chapter 4, Figure 4.6}. The SPSG Province is created by anticyclonic atmospheric circulation and rainfall in the centre of the province is low. The rotation of the gyre deepens the vertical structure of the water column, making the surface waters nutrient poor {Chapter 4}.

Projected changes to surface climate

Air temperatures and rainfall in Samoa are projected to increase due to climate change under the low (B1) and high (A2) emissions scenarios in 2035 and 2100 {see Chapter 1, Section 1.3 for definition of scenarios} relative to long-term averages {Chapter 2, Section 2.5, Table 2.6}.

Climate feature[a]	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Air temperature (°C)	27.0 (Apia)	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Rainfall (mm)	2840 (Apia)	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
		More extreme wet and dry periods			
Cyclones	1.3	➢ Total number of tropical cyclones may decrease ➢ Cyclones are likely to be more intense			

* Approximates A2 in 2050; a = for more detailed projections of rainfall, air temperature and cyclones in the vicinity of Samoa, see www.cawcr.gov.au/projects/PCCSP.



Projected changes to the ocean

The projected changes to the key features of the tropical Pacific Ocean surrounding Samoa relative to the long-term averages are expected to result in increases in sea surface temperature (SST), sea level and ocean acidification. Changes to ocean currents (increases in the South Pacific gyre) and reductions in nutrient supply are also expected to occur {Chapter 3, Sections 3.3 and 3.4, Tables 3.1 and 3.2}.

Ocean feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Sea surface temperature (°C)	28.9[a]	+0.6 to +0.8	+0.7 to +0.8	+1.2 to +1.6	+2.2 to +2.7
Sea level (cm)	+6 since 1960				
IPCC **		+8	+8	+18 to +38	+23 to +51
Empirical models ***		+20 to +30	+20 to +30	+70 to +110	+90 to +140
Ocean pH (units)	8.08	-0.1	-0.1	-0.2	-0.3
Currents	Increase in South Pacific gyre	Continued increase in strength of South Pacific gyre			
Nutrient supply	Decreased slightly	Decrease due to increased stratification and shallower mixed layer			< -20%

* Approximates A2 in 2050; ** projections from the IPCC-AR4; *** projections from recent empirical models {Chapter 3, Section 3.3.8}; a = average for EEZ derived from the HadISST dataset.

Oceanic fisheries

Recent catch and value

Samoa has a local longline fishery targeting albacore tuna within and outside its exclusive economic zone (EEZ). The recent average annual catch (2004–2008) by this fishery has been 2540 tonnes, worth USD 13 million. Samoa also licenses foreign vessels to fish for tuna within its EEZ, although catches by these fleets between 1999 and 2008 averaged only 60 tonnes. See 'Coastal Fisheries' below for contributions of tuna to nearshore artisanal and small-scale commercial fisheries.

Local oceanic fisheries	Average annual catch (tonnes) 2004–2008	Average annual catch value (USD million)* 2004–2008
Tuna		
Longline	2502	13
Other oceanic fish[a]	37	0.04
Total	**2539**	**13.04**

* Calculated using market value per tonne for 2004–2008; a = billfish catch only, valued at USD 1000 per tonne.

Existing oceanic fish habitat

Samoa's EEZ lies within the generally nutrient-poor waters of the SPSG Province {Chapter 4, Figure 4.6}. This province is characterised by downwelling and low nitrate concentrations in deeper waters. Net primary production is low, particularly in summer when there is the formation of a marked thermocline {Chapter 4, Section 4.4.3}. Local upwelling around islands can result in small areas of enriched surface productivity. In general, however, the SPSG Province does not provide prime feeding areas for tuna.

Projected changes to oceanic fish habitat

Under climate change, the surface area of the SPSG Province is projected to increase and extend poleward. Key components of the food web (net primary production and zooplankton biomass) are expected to decrease slightly in SPSG {Chapter 4, Table 4.3}.

SPSG feature	Projected change (%)			
	B1 2035	A2 2035	B1 2100*	A2 2100
Surface area[a]	+4	+7	+7	+14
Location	Poleward extension of southern limit			
Net primary production	-3	-5	-3	-6
Zooplankton biomass	-3	-4	-5	-10

* Approximates A2 in 2050; a = area derived from modelling of nutrients and salinity {Chapter 4, Table 4.3}.

Projected changes in oceanic fisheries production

Preliminary modelling suggests that under the B1 and A2 emissions scenarios, catches of skipjack tuna in the EEZ of Samoa are expected to increase significantly in 2035 and 2100, relative to the 20-year average (1980–2000). Catches of bigeye tuna are projected to remain relatively stable under both scenarios in 2035 and B1 in 2100, and to decrease slightly under A2 in 2100 {Chapter 8, Section 8.7}. Modelling for yellowfin tuna and albacore is now in progress. The trends for yellowfin tuna are expected to be similar to those for skipjack tuna, whereas albacore are expected to move poleward and to be more abundant at the edges of the SPSG Province.

Projected change in skipjack tuna catch (%)			Projected change in bigeye tuna catch (%)		
B1/A2 2035	B1 2100*	A2 2100	B1/A2 2035	B1 2100*	A2 2100
+44	+49	+55	+1	+1	-4

* Approximates A2 in 2050.

Coastal fisheries

Recent catch and value

The coastal fisheries of Samoa are made up mainly of three components: demersal fish (bottom-dwelling fish associated with coral reef, mangrove and seagrass habitats), nearshore pelagic fish (including tuna, rainbow runner, wahoo and mahi-mahi), and invertebrates gleaned from intertidal and subtidal areas {Chapter 9, Section 9.2.1}. The total annual catch was estimated to be 8624 tonnes in 2007, worth > USD 34.5 million. The commercial catch was ~ 4200 tonnes. Demersal fish are estimated to make up ~ 50% of the total catch.

Feature	Coastal fisheries category				Total	Total value (USD m)*
	Demersal fish	Nearshore pelagic fish[b]	Targeted invertebrates	Inter/subtidal invertebrates		
Catch (tonnes)*	4419	2550	0	1655	8624	34.5
Contribution (%)[a]	51	30	0	19	100	

* Estimated total catch and value in 2007 (Gillett 2009)[1]; a = method for calculating disaggregated catch data for each category is outlined in Chapter 9 {Appendix 9.2, Supplementary Table 9.1}; b = catch comprised equally of tuna and non-tuna species.

Existing coastal fish habitat

Samoa has > 460 km^2 of coral reef habitat {Chapter 5}, as well as relatively small areas of mangroves, seagrasses, and intertidal sand and mud flats {Chapter 6} that support important coastal fisheries species.

Habitat	Coral reef[a]	Mangrove[b]	Seagrass[b]	Intertidal flat
Area (km^2)	466	7.5	n/a	n/a

a = Includes barrier, patch and fringing reefs and reef lagoons {Chapter 5, Table 5.1}; b = values from Chapter 6, Table 6.1; n/a = data not available.

Projected changes to coastal fish habitat

Climate change is expected to add to the existing local threats to coral reefs, mangroves, seagrasses and intertidal flats in Samoa, resulting in declines in the quality and area of all habitats {Chapters 5 and 6}.

Habitat feature[a]	Projected change (%)		
	B1/A2 2035	B1 2100*	A2 2100
Coral cover[b]	-25 to -65	-50 to -75	> -90
Mangrove area	-10	-50	-60
Seagrass area	-5 to -20	-5 to -35	-10 to -50

* Approximates A2 in 2050; a = no estimates in reduction of intertidal flats available; b = assumes there is strong management of coral reefs.

Projected changes in coastal fisheries production

Fisheries for demersal fish and intertidal and subtidal invertebrates in Samoa are projected to show progressive declines in productivity due to both the direct effects (e.g. increased SST) and indirect effects (changes to fish habitats) of climate change {Chapter 9, Section 9.5}. On the other hand, the nearshore pelagic fishery component of coastal fisheries is projected to increase in productivity due to the redistribution of tuna to the east {Chapter 8}.

Coastal fisheries category	Projected change (%)			Main effects
	B1/A2 2035	B1 2100*	A2 2100	
Demersal fish	-2 to -5	-20	-20 to -50	Habitat loss and reduced recruitment (due to increasing SST and reduced currents)
Nearshore pelagic fish[a]	+15 to +20	+20	+10	Changes in distribution of tuna
Inter/subtidal invertebrates	0	-5	-10	Declines in aragonite saturation due to ocean acidification

* Approximates A2 in 2050; a = tuna dominate the nearshore pelagic fishery {Chapter 9, Tables 9.8 and 9.10}.

The overall projected change to coastal fisheries catch reflects the relative importance of demersal fish, balanced in the short term by the projected increase in productivity of the nearshore pelagic component of the fishery. As a result, total catches from coastal fisheries in Samoa are projected to increase slightly under both scenarios in 2035 but decline under both scenarios in 2100, particularly under A2 in 2100.

Coastal fisheries category	Contrib. (%)**	Projected change in productivity (P) and catch (%)					
		B1/A2 2035		B1 2100*		A2 2100	
		P***	Catch	P***	Catch	P***	Catch
Demersal fish	51	-3.5	-2	-20	-10	-35	-18
Nearshore pelagic fish	30	+17.5	+5	+20	+6	+10	+3
Inter/subtidal invertebrates	19	0	0	-5	-1	-10	-2
Total catch[a]			**+3**		**-5**		**-17**

* Approximates A2 in 2050; ** contribution of each component to total coastal fisheries catch in Samoa; *** median projected change in productivity based on range in Chapter 9; a = assumes that proportion of each category remains constant.

Freshwater and estuarine fisheries

Recent catch and value

The main freshwater and estuarine species caught in Samoa include tilapia, eels and *Macrobrachium*. These species are mostly taken by subsistence fisheries. The estimated annual freshwater fish catch in 2007 was 10 tonnes, worth USD 33,200 {Chapter 10}[1].

Existing freshwater and estuarine fish habitat

The larger rivers of Samoa provide a limited range of freshwater and estuarine fish habitats for supporting fish and invertebrate communities {Chapter 7, Table 7.1}.

Island	Largest river	Catchment area (km^2)	River length (km)
Savai'i	Sili	51	11
Upolu	Vaisigano	33	12

Projected changes to freshwater and estuarine fish habitat

The projected increase in rainfall for Samoa {Chapter 2, Section 2.5.2} is expected to result in small increases in the area and quality of all freshwater fish habitats {Chapter 7, Table 7.5}. Sea-level rise is expected to increase the area of estuarine habitat {Chapter 7}.

Projected changes to freshwater and estuarine fish habitat area (%)		
B1/A2 2035	B1 2100*	A2 2100
-5 to +5	-5 to +5	-5 to +10

* Approximates A2 in 2050.

Projected changes in freshwater and estuarine fisheries production

Higher projected rainfall and river flows are expected to result in slightly improved production from freshwater and estuarine fisheries in Samoa under the A2 emissions scenario in 2100. River flow increases the availability and quality of habitats, provides cues for fish migration, and enhances reproduction and recruitment {Chapter 10, Section 10.5}.

Projected changes in freshwater and estuarine fish catch (%)		
B1/A2 2035	B1 2100*	A2 2100
0	0	+2.5

* Approximates A2 in 2050.

Aquaculture

Recent and potential production

Aquaculture activities in Samoa centre on pond aquaculture of tilapia for food security. Production of marine ornamentals (e.g. giant clams) in coastal waters has also been investigated but commercially viable operations have yet to be established.

Existing and projected environmental features

Higher rainfall and air temperatures are expected to have positive effects on the growth and survival of tilapia. However, increasing SST, rainfall and ocean acidification, and possibly stronger storm surge from more severe cyclones, are eventually expected to reduce the number of sites where ornamental products can be successfully grown {Chapter 11}.

Environmental feature	1980–1999 average	Projected change			
		B1 2035	A2 2035	B1 2100*	A2 2100
Air temperature (°C)	27.0[a]	+0.5 to +1.0	+0.5 to +1.0	+1.0 to +1.5	+2.5 to +3.0
Annual rainfall (mm)	2840[a]	+5 to +15%	+5 to +20%	+10 to +20%	+10 to +20%
Cyclones (no. per year)	1.3	➢ Total number of tropical cyclones may decrease ➢ Cyclones are likely to be more intense			
Sea surface temperature (°C)	28.9	+0.6 to +0.8	+0.7 to +0.8	+1.2 to +1.6	+2.2 to +2.7
Ocean pH (units)	8.08	-0.1	-0.1	-0.2	-0.3

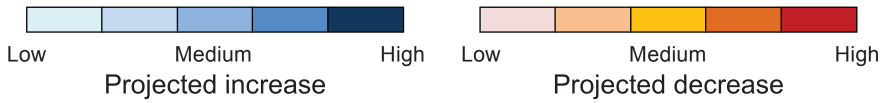
* Approximates A2 in 2050; a = data for Apia.

Projected changes in aquaculture production

The projected effects of climate change on aquaculture are mixed. Pond aquaculture is expected to be enhanced by increased rainfall, river flows, and warmer temperatures, provided ponds are located where they will not be affected by floods or storm surge. Potential commodities for coastal aquaculture are likely to be affected adversely by climate change {Chapter 11, Table 11.5}.

Aquaculture commodity	Use	Projected change		
		B1/A2 2035	B1 2100*	A2 2100
Existing				
Tilapia	Food security			
Potential				
Marine ornamentals	Livelihoods			

* Approximates A2 in 2050.



Economic and social implications

Economic development and government revenue

Current contributions

The locally-based longline fishery for tuna contributed 0.6% to the gross domestic product (GDP) of Samoa in 2007 {Chapter 12}. Licence fees from foreign vessels in the surface fishery contributed > 0.1% and fees from longline vessels contributed 0.02% to government revenue (GR).

Industrial fishery	Contribution to GDP*		Contribution to GR**	
	USD m	GDP (%)	USD m	GR (%)
Surface	0	0	0.3	0.1
Longline	3.3	0.6	0.04	0.02

* Information for 2007, when national GDP was USD 524 million (Gillett 2009)[1]; ** information for surface fishery for 2007, when total GR was USD 168 million, information for longline fishery is for 2003.

Projected effects of climate change

Projected changes to the contribution of tuna fisheries to GDP and GR due to the effects of climate change on the distribution and abundance of tuna are negligible. This is due largely to the small contribution that these fisheries make to the economy of Samoa {Chapter 12}.

Food security

Samoa is among the group of PICTs (Group 3) where the estimated sustainable production of fish and invertebrates from coastal habitats is unable to supply the national population with the 35 kg of fish per person per year recommended for good nutrition[i] {Chapter 12, Section 12.7.1}.

i Based on fish contributing 50% of dietary protein as recommended by the SPC Public Health Programme (SPC 2008)[25].

Current contributions of fish to food security

Average national fish consumption in Samoa is estimated to be 87 kg per person per year[2], well above the recommended levels for good nutrition. At present, coral reefs in Samoa are estimated to be able to supply only 33 kg of fish per person per year. Much of the additional fish is tuna supplied by the nearshore pelagic fishery.

Fish consumption per person (kg)			Fish provided by subsistence catch (%)	
National	Rural	Urban	Rural	Urban
87	98	46	47	21

Effects of population growth

Samoa will have an increasing total demand for fish to meet the recommended 35 kg per person per year in the future due to predicted population growth. The current estimated shortfall of 2 kg per person per year in production of fish from coral reefs increases to 5 kg in 2035, 6 kg in 2050 and 10 kg in 2100.

Variable	2010	2035	2050	2100
Population (x 1000)	183	202	210	240
Fish available per person (kg/year)[a]	33	30	29	25
Gap (kg/person/year)[b]	2	5	6	10

a = Based on 3 tonnes of fish per km^2 of coral reef habitat {Chapter 9}; b = relative to recommended consumption of 35 kg per person per year.

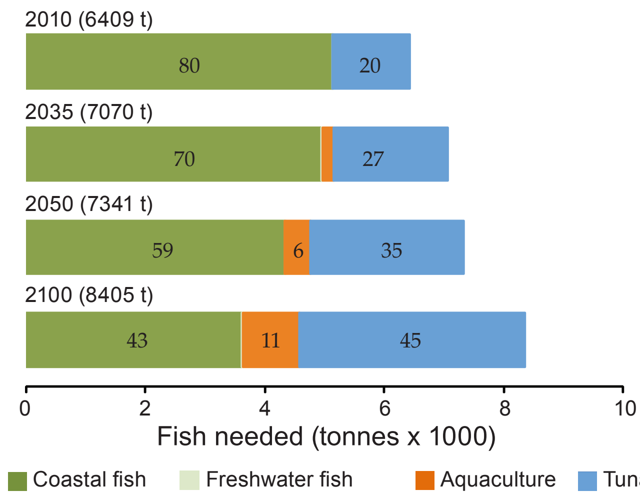
Additional effects of climate change

Samoa faces further declines in the fish available per person due to the combined effects of population growth and climate change. By 2050, climate change will cause the gap between the fish needed per person for good nutrition, and the fish available from coral reefs, to increase from 6 to 10 kg per person per year. In 2100, this gap increases from 10 to 16 kg.

Filling the gap

Tuna is the main resource available to Samoa to help supply the shortfall in fish from coastal habitats for food security. Potential also exists for pond aquaculture to provide a limited amount of fish (11% of total demand by 2100).

The implication is that an increasing proportion of the annual average tuna catch will need to be allocated over time to provide the quantities of fish recommended for good nutrition of Samoa's population. The proportions of the total amount of fish needed for food security to be contributed by tuna reach 27% in 2035, 35% in 2050, and 45% in 2100.



Fish (in tonnes) needed for future food security in Samoa, and the recommended contributions (%) of fisheries resources and aquaculture production to meet future needs.

Livelihoods

Current contributions

Large numbers of full-time and part-time jobs have been created through tuna fishing and processing in Samoa, although they represent only a low percentage of total employment in the nation. Coastal fisheries also provide important opportunities to earn income for coastal communities with ~ 50% of households in representative coastal areas deriving either their first or second source of income from catching and selling fish. Aquaculture has created relatively few jobs[4].

Jobs on tuna vessels			Jobs in shore-based tuna processing			Coastal households earning income from fishing (%)			Jobs in aquaculture*
2002	2006	2008	2002	2006	2008	1st	2nd	Both	2007
674	110	255	108	90	40	24	27	51	16

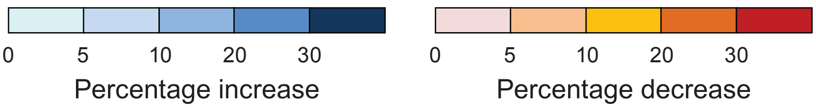
* Ponia (2010)[4]; information derived from Chapter 12, Table 12.6 and the SPC PROCFish Project.

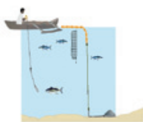
Projected effects of climate change

The effects of climate change on the potential to create more livelihoods based on fisheries and aquaculture are difficult to estimate because there is still scope to derive new jobs from oceanic fisheries, the nearshore component of coastal fisheries and pond aquaculture. However, the A2 emissions scenario is expected to eventually enhance or retard these opportunities as indicated below.

Year	Projected change under A2 scenario			
	Oceanic fisheries**	Coastal fisheries		Aquaculture
		Nearshore pelagic fish	Other resources	(ponds)
Present*	⇧	⇧	⇩	⇧
2035	⬆	⬆	⬇	⬆
2050	⬆	⬆	⬇	⬆
2100	⬆	⬆	⬇	⬆

* Indicates general direction of new opportunities for livelihoods based on the activity; ** based on projected changes in skipjack tuna catches; freshwater and estuarine fisheries not included due to their subsistence role.





Adaptations and suggested policies

The plans Samoa has to derive greater socio-economic benefits from fisheries and aquaculture will depend heavily on interventions to:

1. maximise access to tuna, and the efficiency of fishing operations, to provide fish for economic development and continued food security;
2. manage coastal fish habitats and fish stocks to optimise their contributions to food security; and
3. increase the number of livelihoods that can be based on fishing, tourism and pond aquaculture.

The adaptations and suggested policies to achieve these plans under a changing climate are summarised below (see Section 3 for details).

Economic development and government revenue

Adaptation no. (Section 3.2)	Summary of adaptation	Supporting policy no. (Section 3.3)
E1	Full implementation of sustainable fishing effort schemes	E1, E2, E4–E6
E3	Immediate conservation management measures for bigeye tuna	E8
E4	Energy efficiency programmes for industrial tuna fleets	E9
E5	Environmentally-friendly fishing operations	
E7	Safety at sea	E10
E8	Climate-proof infrastructure	E11
E9	Pan-Pacific tuna management	E2

Food security

Adaptation no. (Section 3.4)	Summary of adaptation	Supporting policy no. (Section 3.5)
F1	Manage and restore vegetation in catchments	F1, F2, F18
F2	Foster the care of coastal fish habitats	F1–F3, F18
F3	Provide for landward migration of coastal fish habitats	F4, F5, F18
F4	Allow for expansion of freshwater habitats	F4, F18
F5	Sustain production of coastal demersal fish and invertebrates	F6, F7, F13, F18
F6	Diversify catches of coastal demersal fish	F6, F13, F18
F7	Manage freshwater and estuarine fisheries to harness opportunities	
F8	Increase access to tuna for urban and rural populations	F8–F13, F18
F9	Develop pond aquaculture to diversify the supply of fish	F13–16, F18
F10	Develop coastal fisheries for small pelagic fish	F13, F17, F18
F11	Improve post-harvest methods	F17, F18

Sustainable livelihoods

Adaptation no. (Section 3.6)	Summary of adaptation	Supporting policy no. (Section 3.7)
L1	Improve technical and business skills of communities	L1, L2
L2	Rebuild populations of sea cucumbers and trochus	L2
L3	Develop coral reef ecotourism ventures	L3
L4	Diversify production of coastal aquaculture commodities	L4, L5