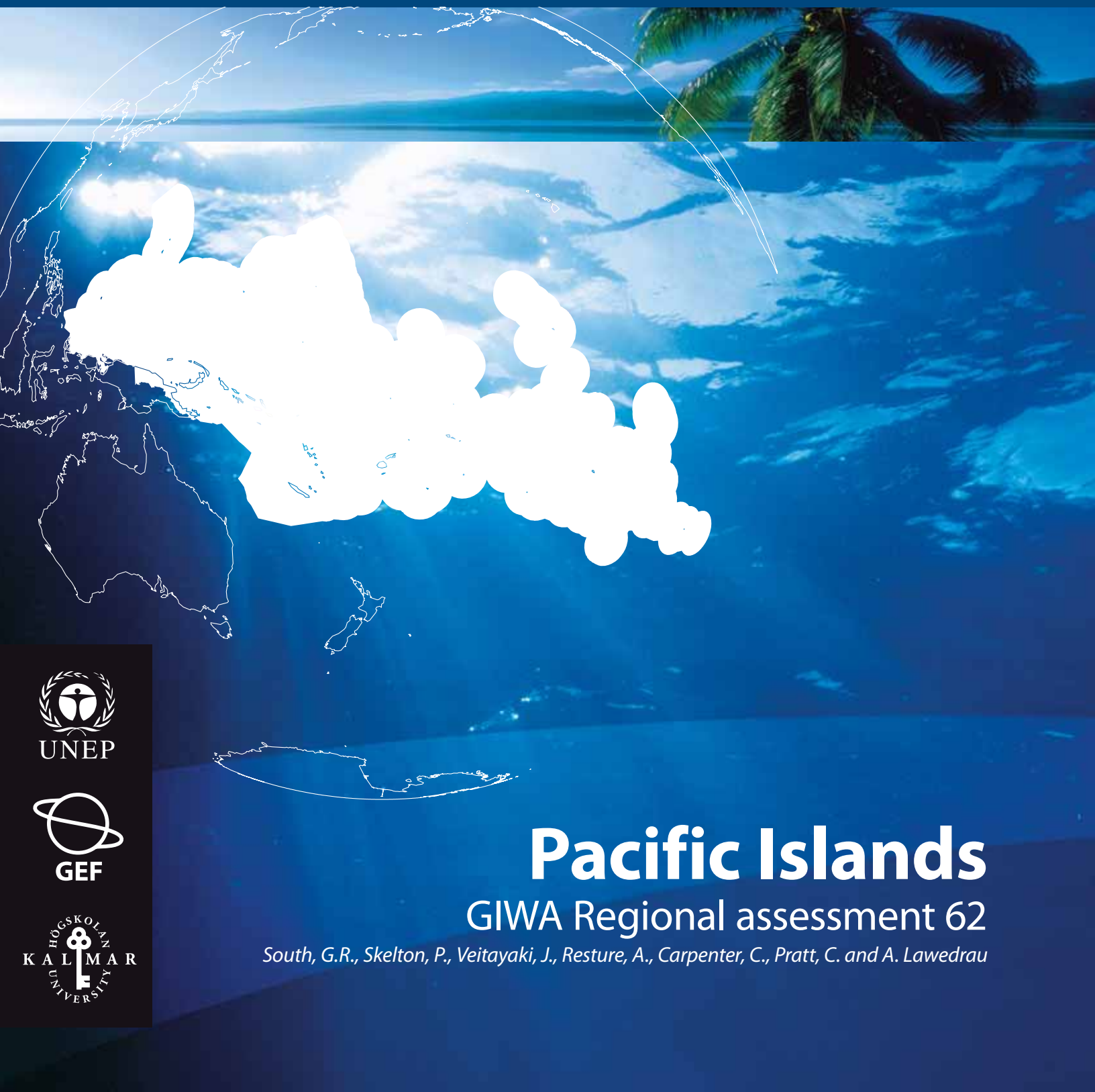
GIWA

Global International Waters Assessment



UNEP

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Pacific Islands

GIWA Regional assessment 62

South, G.R., Skelton, P., Veitayaki, J., Resture, A., Carpenter, C., Pratt, C. and A. Lawedrau

Global International Waters Assessment

Regional assessments

Other reports in this series:

Barents Sea – GIWA Regional assessment 11

Caspian Sea – GIWA Regional assessment 23

Gulf of California/Colorado River Basin – GIWA Regional assessment 27

Patagonian Shelf – GIWA Regional assessment 38

Brazil Current – GIWA Regional assessment 39

Amazon Basin – GIWA Regional assessment 40b

Guinea Current – GIWA Regional assessment 42

Lake Chad Basin – GIWA Regional assessment 43

Indian Ocean Islands – GIWA Regional assessment 45b

East African Rift Valley Lakes – GIWA Regional assessment 47

Global International Waters Assessment

Regional assessment 62
Pacific Islands

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Global International Waters Assessment
Pacific Islands, GIWA Regional assessment 62

Published by the University of Kalmar on behalf of
United Nations Environment Programme

ISSN 1651-940X

University of Kalmar
SE-391 82 Kalmar
Sweden

United Nations Environment Programme
PO Box 30552,
Nairobi, Kenya

CITATIONS
When citing this report, please use:
UNEP, 2004. South, G.R., Skelton, P., Veitayaki, J., Resture, A., Carpenter, C., Pratt, C. and A. Lawedrau. Pacific Islands, GIWA Regional assessment 62. University of Kalmar, Kalmar, Sweden.

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Printed and bound in Kalmar, Sweden, by Sunds Tryck Öland AB.

Contents

Executive summary

The Pacific Islands GIWA region 62 includes all of the 23 island nations or territories of the tropical Pacific Ocean that embrace the cultural areas of Melanesia, Polynesia and Micronesia. The region covers about 12% of the world's ocean space. These island states and territories range from very large, high continental islands, to countless offshore large and small islands that may be generally grouped as high islands, coral lime stone islands and atolls. The total land areas vary from 12 to 26 km^2 for groups of low-lying coral-limestone islands like Tokelau and Tuvalu to over 400 000 km^2 for the continental island areas of Irian Jaya and Papua New Guinea. Terrestrial, freshwater and marine ecosystems are highly variable, and there is also a wide range of geographic, demographic and developmental diversity. Some, like Easter Island, Guam, Kosrae, Nauru and Niue, consist of one single small island. Others like Fiji, Tonga and French Polynesia are comprised of numerous large and small highly dispersed islands. Papua New Guinea and West Papua (Irian Jaya) are parts of high continental islands. These geographic and topographic differences are paralleled by differences in climate, geological resources, topographical features, soil types, mineral and water availability, extent of coral reefs and diversity of terrestrial, freshwater and marine flora and fauna.

As the boundaries of the region are largely adjoining other large oceanic spaces, transboundary effects are minimal on this scale. The unpopulated Coral Sea situated to the west of the region minimises any transboundary effects from the continent of Australia, but to the northwest the region is influenced by land-based factors such as run-off from land-based activities (forestry, mining) and sedimentation originating from Papua New Guinea, Irian Jaya, and the Philippine Sea. Given that there are large areas of deep ocean space separating the island states and territories, any transboundary effects are minimised. Within the larger archipelagic states, however, local transboundary effects are potentially significant, as urban impacts, large watershed effects and other anthropogenic disturbances such as mining, forestry, agriculture and coastal development may affect adjacent areas.

Population densities range from extremely low to numbers comparable with some of the densest metropolitan areas in the world. The range is from just over 8 persons per km^2 for Pitcairn Island to 505 persons per km^2 for Nauru. In the most populous islands, the densities rise to over 100 per km^2 for four islands, over 200 for three islands, and 421 for Koror in Palau, 757 for Funafuti in Tuvalu, 1 179 for Majuro in the Marshall Islands, and 2 190 for Tarawa in Kiribati. The estimated population for Betio Islet of Tarawa atoll was 40 000 in the year 2000, which will give it a population density rivalling those of Hong Kong and Singapore. On Ebeye, one of some 90 islets comprising Kwajalein Atoll in the Marshall Islands, and to which people have been relocated by the U.S. military to free the atoll's lagoon for intercontinental ballistic missile testing, the population density increases to over 25 000 per km^2!

Although some of the larger island groups with significant mineral, forestry, fisheries and agricultural land resources have some potential for development, most Pacific Island states and territories do not. Their options for modern economic development are extremely limited because of their small size, geographic isolation and extremely limited natural resources. Thus most island countries, territories and local communities will, for the foreseeable future, have to depend on the sustainable use of their local resources as a basis for their survival and development. The Pacific Island region is unique in that most of the islands of the region are inhabited by indigenous peoples who have close links with, and great cultural, economic and spiritual dependence on their island terrestrial and marine environment. Generally speaking, these indigenous people are the owners and users of these resources and ultimately control decisions related to their conservation and sustainable use. This is a very different situation compared with that in other GIWA island regions, such as the Indian Ocean and the Caribbean Sea, and continental areas where there is more private or public land and governments can play a much greater role in resource management.

It was noted during the assessment of GIWA issues that there was a great disparity in the impacts of various issues across the region because of the diverse range and varying characteristics of the islands comprising the region. For example, freshwater shortage may be ranked highly in atoll states, but lower in the high island states. Important socio-economic issues in the region include high population growth rates, urban drift, breakdown of traditional lifestyles, a strong dependence on aid and the rapid adoption of the cash economy.

The Causal chain analysis concentrated on selected case studies:

- Freshwater shortage: Viti Levu, Fiji and South Tarawa, Kiribati;
- Unsustainable exploitation of fish: Fiji.

Root causes for freshwater shortage include rapid economic development, increases in population density (and hence demands for water) through migration and urban drift, lack of adequate policies on land and water use and the necessary capacity for their enforcement, and natural phenomena including changing weather patterns and other aspects of climate change. Pollution of water supplies is potentially region-wide, due to inadequate treatment of domestic waste water and inadequate solid waste disposal. Changes in the water table from over-use and climate-related issues are widespread, but the most threatening are in atoll countries. There are some significant examples of habitat modification leading to loss of ecosystems: some are attributable to unregulated coastal development, destruction of mangroves, forestry, mining and poor wastewater discharge. Economic development and market demand (eg. logging, mining, tourism) are also root causes.

Unsustainable exploitation of fish is universal throughout the region, and most serious close to urban areas. A root cause is the need to generate income to support family needs, this causing a decline in coastal resources. Destructive fishing, overexploitation, lack of enforcement, lack of Marine Protected Areas (MPAs) and over-licensing are all evident from the analysis, and the root causes include market demand, lack of regulations and/or their enforcement, and economic demand. Access to technology was also seen as a root cause. Pollution is affecting living resources in some heavily populated areas like Suva, Fiji. This includes heavy metals, human waste, solid waste and agricultural run-off. A lack of regulation and increasing population pressure are among the most important root causes. There is often also a lack of political will.

With respect to policies, it is clear that stakeholders should be involved in their development and implementation. Where adequate policies do exist, enforcement is rarely successful and governments are driven by expedience or economics. Above all, lack of knowledge (which leads to a lack of appreciation of the long-term effects of current actions) is a pervasive problem and capacity building needs to be given a high priority now and for the foreseeable future. Integrated planning is rarely, if ever, practised throughout the region and there is a long timelag between signing and ratifying global conventions and agreements, and then developing the national laws and regulations needed to regulate and enforce them. In some areas, such as land and resource ownership issues, dispute resolution is an on-going need. In the area of resource overexploitation, the same governance and regulatory issues are important. A lack of data describing the status of fisheries is a major problem for stakeholders and regulators alike. Co-management is seen as an important strategy to be adopted for the future. A lack of MPAs gives the countries little protection against loss of resources and biodiversity.

The recommendations are designed to address the root causes identified in the GIWA assessment. They are not listed in any particular order of priority. It is noteworthy that most of them are also reflected in the Pacific Islands Regional Ocean Forum, held in Suva, Fiji on February 2-6, 2004.

1. All Pacific Island countries urgently need to develop and implement laws and regulations necessary for their compliance with global conventions and agreements to which they are signatory. Existing legislation should be properly enforced, and where new legislation is required, this will require substantial outside assistance, since many countries lack the necessary legal expertise.
2. Capacity building in all areas of ocean, coastal and watershed management is a priority for the region. This will require a concerted effort on the parts of national, regional and international education and training institutions, and significant funding. All future projects should be required to include a capacity building component and should engage local communities.
3. The raising of public awareness on all coastal and ocean-related topics is badly needed, from the level of the village to that of government, planners and decision-makers. Schools, NGOs and the media should all play a part in this process. For the schools, this would require a significant investment in the development of national school curricula that reflect local needs.
4. Integrated planning and decision-making is a necessity for all governments. This requires a new paradigm in government, and involvement of all parties in the process, especially the stakeholders. For most countries, the development of an integrated coastal management plan should be a national priority.
5. There is a great need for research on and monitoring of the coastal and ocean environments of the region. The strengthening

of research and monitoring capacity is an a priore need and, where necessary, regional and international cooperation and involvement of communities, NGOs and the private sector should be encouraged. The need should be expressed in all future bi-lateral and multi-lateral aid projects, and funding sought to support it. The strengthening of the research and monitoring capacity of national and regional universities should be encouraged, as well as cooperation with developed country institutions through partnership arrangements.

6. The regional and global lobbying of the Pacific Island countries is commendable, well organised and effective. This now needs to be brought down to the local community level, and proper feedback mechanisms between researchers, managers, government and communities need to be developed.
7. Environmental sustainability needs to be given greater emphasis by governments, many of which lack a relevant ministry or department for the environment. Implementation of sustainability policies will require political will, cooperation, and the provision of appropriate resources.
8. All Pacific Island countries developed National Environment Management Strategies (NEMS) as a lead-up to UNCED. Yet, many of the recommendations have yet to be implemented, and the NEMS are a decade out of date. The NEMS should be dusted off, revised if necessary, and translated into actions. The recommendations contained within NEMS could be linked to economic development plans, in the form of National Sustainable Development Plans.
9. Pacific Island countries must take greater ownership of projects managed by regional organisations, as it is the countries themselves who will have to implement sustainable practices. Countries must strive and seek support to bring this about, because if they fail to do so it could at their peril for the future.

Abbreviations and acronyms

ACP	sub-Saharan Africa, Caribbean and Pacific states
ADB	Asian Development Bank
ARGO	Array of Real-Time Global Observation
ARM	United States Department of Energy's Atmospheric Radiation Measurement
ASEAN	Association of Southeast Asian Nation
BOD	Biological Oxygen Demand
CMT	Customary Marine Tenure
CPUE	Catch Per Unite Effort
CROP	Council of Regional Organisations of the Pacific
EDP	European Development Fund
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
FLMMA	Fiji's Locally Managed Marine Area
FSM	Federated States of Micronesia
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GMA	Global Marine Assessment
GPA	Global Programme of Action
IMO	International Maritime Organization
IGOs	Inter-Governmental Organisations
IPCC	Inter-governmental Panel on Climate Change
ISA	Integrated Strategic Action
IUCN	International Union for Conservation of Nature
IW	International Waters
JPfA	Joint Caribbean Pacific Programme for Action on Water and Climate
LMMA	Locally Managed Marine Areas
MPA	Marine Protected Areas
MSY	Maximum Sustainable Yield
NEMS	National Environment Management Strategies
NGOs	Non-Governmental Organisations
NPA	National Plans of Action
ODS	Ozone Depleting Substances
PACPOL	Pacific Ocean Pollution Prevention Programme
PIDCs	Pacific Islands Developing Countries
PIROF	Pacific Islands Regional Ocean Forum
PIROP	Pacific Islands Regional Ocean Policy
PNG	Papua New Guinea
RMI	Republic of the Marshall Islands
SAP	Strategic Action Programme
SEREAD	Scientific Educational Resources and Experience Associated with the Deployment of ARGO
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat for the Pacific Community
SPREP	South Pacific Regional Environment Programme
TAC	Total Allowable Catch
TAG	Technical Advisory Group
TBT	Tributyl tin
TWP	Tropical Western Pacific
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

List of figures

List of tables

Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Pacific Islands region

The geographical focus of GIWA region 62 the Pacific Islands region (Figure 1) includes all of the island nations or territories of the tropical Pacific Ocean that are considered part of the "cultural areas" of Melanesia, Polynesia and Micronesia (Table 1). The Pacific

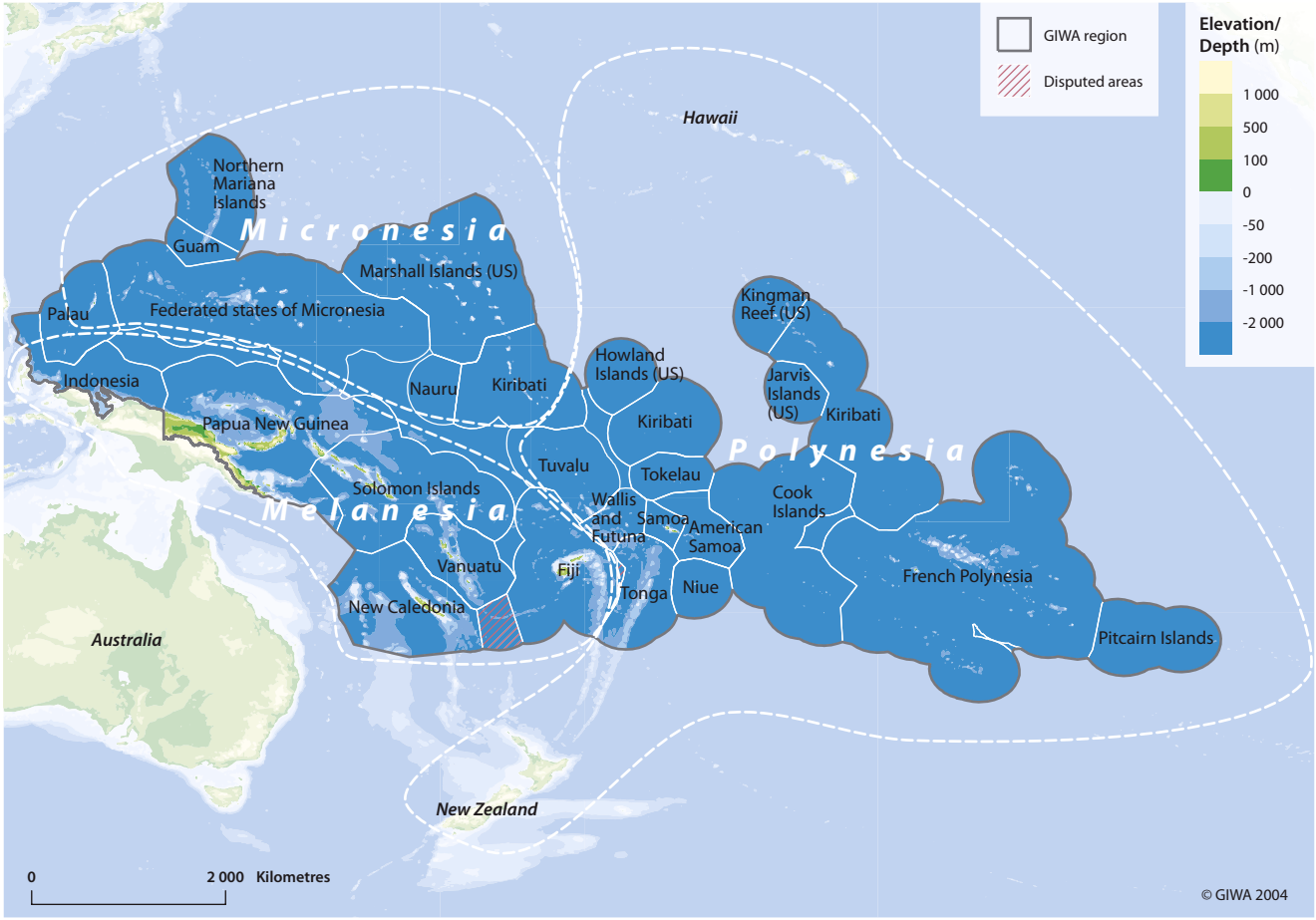

Figure 1 Boundaries of the region.

Table 1 Geographic and economic statistics for the countries and territories of the region.

Country	Land area (km^2)	Population	Population density (per km^3)	Annual growth rate (%)	Total GDP (USD)	GDP per capita (USD)
American Samoa	199	70 260	353	2.22	500 000	8 000
Cook Islands	240	21008	88	1.1	105 000	5 000
Federated States of Micronesia	702	108 143	154	0.04	277 000	2 000
Fiji	18 270	868 531	48	1.41	4 800 000	5 600
French Polynesia	4 167	262 125	63	1.62	1 300 000	5 000
Guam	549	163 941	299	1.89	3 200 000	21 000
Kiribati	811	98 549	122	2.26	79 000	800
Marshall Islands	181	56 429	311	2.3	115 000	1 600
Nauru	21	12 570	599	1.9	60 000	5 000
Niue	260	2 145	8	0.01	7 600	3 600
Northern Mariana Is.	477	80 006	168	3.37	900 000	12 500
New Caledonia	19 060	210 798	11	1.38	3 000 000	14 000
Palau	458	19 717	43	1.54	174 000	9 000
Papua New Guinea	462 840	5 295 816	11	2.34	10 860 000	2 100
Pitcairn	47	47	1	ND	ND	ND
Samoa	2 944	178 173	61	-0.27	1 000 000	5 600
Solomon Islands	28 450	509 190	18	2.83	800 000	1 700
Tokelau	10	1 418	142	0.01	1 500	1 000
Tonga	748	108 141	145	1.9	236 000	2 200
Tuvalu	26	11 305	435	1.42	12 200	1 100
Vanuatu	12 200	199 414	16	1.61	563 000	2 900
Wallis and Futuna	274	15 734	57	1.3	30 000	2 000

Note: ND = No Data.

(Source: Dalzell et al. 1996, CIA World Factbook 2003)

Islands region, as considered here, lies between 130° E and 125° W and includes all associated offshore and ocean areas. The western boundary of the region is West Papua (Irian Jaya) the western half of the island of New Guinea, which is part of Indonesia, but geologically, biogeographically and culturally related to Melanesia, and the offshore islands of Papua New Guinea the northeastern half of New Guinea. The eastern boundary is demarcated by Pitcairn Island and its Exclusive Economic Zone (EEZ). Adjacent to the region are the Hawaiian Archipelago , New Zealand, Australia, Torres Strait Islands and southern Papua New Guinea.

Physical characteristics

Island types

Within region 62, there is a great diversity of island types and corresponding terrestrial, freshwater and marine ecosystem and habitat diversity:

- Geologically-ancient continental islands composed of sedimentary, metamorphic, and igneous rocks of continental origin, such as Papua New Guinea and New Caledonia;
- Older volcanic islands, such as most of the islands of Fiji, Vanuatu, Solomon Islands, the eastern islands of Papua New Guinea (e.g. Manus, New Britain, and Bougainville), Guam, and the Northern Marianas;
- Recent high basaltic volcanic "hot spot" islands, such as the Samoan archipelago, the Cook Islands, Tahiti in French Polynesia, and Pohnpei and Kosrae in the Federated States of Micronesia;
- Raised limestone islands, such as Nauru, Niue, most of the Tonga and Palau groups, and Aniwa in Vanuatu;
- Low-lying coral-limestone islands, such as most of the true atolls and islands that have no lagoons in the Marshall Islands, Kiribati, Tuvalu, Tokelau and the Tuamotus in French Polynesia. Each has its own characteristic biota and ethno-biological traditions.

There is also great geographic, demographic and developmental diversity (Table 1). Some "groups" or countries like Guam, Nauru and Niue, consist of one single small island. Some like Fiji, Tonga and French Polynesia are comprised of numerous large and small highly dispersed islands. Others like Papua New Guinea (PNG) and West Papua (Irian Jaya) consist of parts of very large, high continental islands, plus countless offshore large and small islands. The total land areas vary from 12 to 26 km^2 for groups of low-lying coral-limestone islands like Tokelau and Tuvalu, to over 400 000 km^2 for the continental island areas of Irian Jaya and Papua New Guinea. Great differences in climate, geological resources, topographical features, soil types, mineral and water availability, extent of coral reefs and diversity of terrestrial, freshwater and marine flora and fauna are also found in the area.

Climate

The average annual rainfall in the region varies from just over 1 000 mm in New Caledonia to 5 000 mm in Pohnpei and Kosrae States in the Federated States of Micronesia (FSM). Rainfall can vary dramatically on large islands (such as on Viti Levu Island of Fiji, with 3 200 mm in the east, and 1 900 mm in the west), between different islands in the same archipelago, and annually (e.g. the atolls of Kiribati, which may experience prolonged droughts). These variations in rainfall lead to

variations in coastal productivity, with the highest being found in the lagoons and embayments of high islands (Dalzell et al. 1996).

Climatic seasonality is more pronounced in the higher latitudes, but even in the equatorial area seasonal differences occur, such as changes in prevailing winds and rainfall. For most of the year, the region is influenced by the Southeast Trade winds, but for 4 to 5 months during the northern winter, by the Northwest Monsoon (Dalzell et al. 1996).

Large-scale climatic events such as cyclones occur regularly in the western tropical Pacific, and up to 18 per year may form in the northwest Pacific. South of the Equator they occur from December to April, and average four per year (Wauthy 1986). The El Niño Southern Oscillation (ENSO) has a profound influence on the coastal and marine environments of the Pacific Islands (Dalzell et al. 1996). The southern oscillation index is a measure of the atmospheric pressure difference between Darwin (Australia) and Tahiti (French Polynesia), which is positive in normal years. During an ENSO episode this gradient reverses, with a resulting shift in climatic and oceanic conditions. Important effects are unseasonable droughts in the western Pacific, and unseasonable rains in the central and eastern Pacific. There is strong evidence that ENSO events can have both positive and negative impacts on the pelagic fishery, with stocks of migratory species such as Skipjack and Yellow fin tuna shifting eastwards during an ENSO episode. The increasing occurrence of cyclones and ENSO events in recent years may be evidence of the impact of global change on the Pacific Islands region, although recent paleoclimatic analyses of corals indicate that ENSO events have been more frequent in the past.

Hydrological characteristics

Wauthy (1986) has summarised the hydrological characteristics of South Pacific marine environments. The surface waters of the tropical west and central Pacific enter into the trans-Pacific inter-tropical circulation from the eastern boundaries of two sub-tropical anticyclonic gyres. The surface waters are isolated from deeper layers by a well established thermocline and, as they move from east to west, they grow warmer and more nutrient deficient. This leads to very clear blue oceanic water, where average primary production ranges from 20 to 50 gC/m^2/year (FAO 1972). Upwelling can enrich these impoverished waters, and a shallowing of the thermocline allows nutrients to reach the euphotic zone at the edges of the equatorial counter-currents. Nutrient input from precipitation and run-off is possible only in the waters surrounding the large island archipelagos of Melanesia. The highest primary production in the region ranges from 90 to 180 gC/m^2/year on the shelf area of the Gulf of Papua, which receives much of the drainage from the PNG highlands region (Dalzell et al. 1996).

Nearly all of the Pacific Islands region falls within the tropics, and sea surface temperatures rarely fall below 20°C, and may rise as high as 30°C at times; shallow waters of lagoons and fringing reefs may reach higher temperatures, up to 38°C during low tides (South, pers. obs.).

Coastal biota

The coastal biota are characterised by coral reefs, seagrass meadows and mangrove forests. The biodiversity of these habitats diminishes from west to east, since the centre of species biodiversity is in the Indo-West Pacific region, which borders on the western and northwestern boundary of the Pacific Islands region. National and international protected areas in the Pacific Islands region are shown in Figure 2.

Coral reefs

The corals and coral reefs of the Pacific Islands are described in Wells and Jenkins (1988) and Spalding et al. (2001). The status of Pacific Island reefs is reported in Wilkinson (1998, 2000, 2002). In Melanesia, biodiversity is high and diminishes towards the east. The reefs of New Caledonia and Fiji are the best studied, but there remain vast areas of unexplored reefs (Spalding et al. 2001). The majority of Melanesian reefs are under traditional stewardship and the reefs serve as important sources of food for subsistence fishers. Attempts to establish marine protected areas (MPAs) in Melanesia have had limited success, although the rights of villagers to manage their own near-shore resources are now widely recognised, leading to co-management regimes.

In Micronesia, reefs are well developed, except on coastlines affected by active volcanism. Palau lies closest to the centre of reef diversity in the Indo-Pacific region; as in Melanesia, species biodiversity declines eastwards. According to Spalding et al. (2001), there are considerable differences in the state of Micronesian reefs and, for those under the control of the United States, the impacts of humans are most marked. A breakdown of traditional systems has occurred in most countries following the shift from traditional village life to an urban lifestyle, and the impact of military activities has been critical, especially in those areas of the Marshall Islands used for intensive nuclear testing in the 1940s and 1950s. Away from areas of human impact, however, a large number of reefs remain in good to excellent condition. Polynesia comprises an enormous region of widely scattered islands from Wallis and Futuna to Hawaii (not included in this report) to French Polynesia and, to the south, Tonga. According to Spalding et al. (2001), Polynesia includes 11 000 km^2 of coral reefs, with every kind of island and reef type represented.

Traditional utilisation and management of reefs has been lost in many of the islands, following the breakdown of traditional lifestyles and

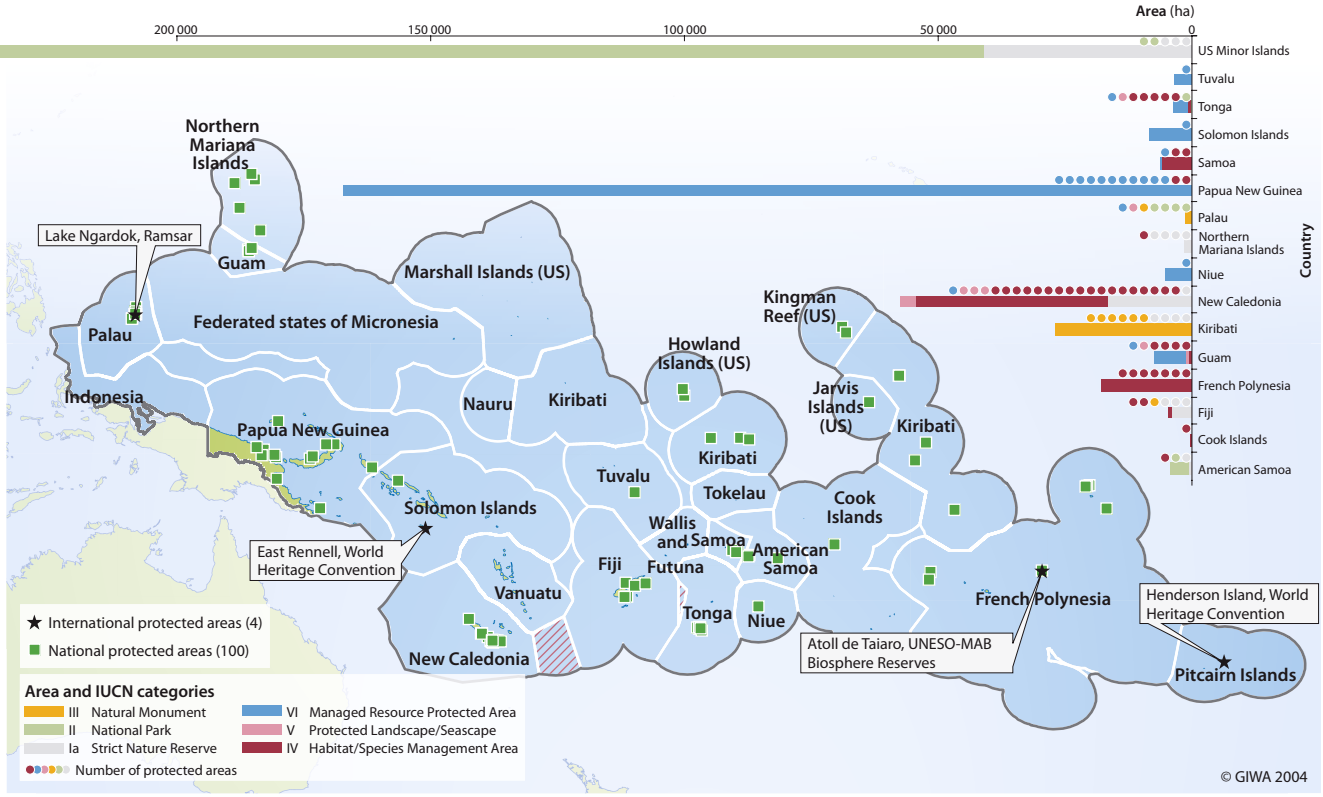

Figure 2 National and international protected areas in the Pacific Islands region with a marine component, categorised according to IUCN. The diagram shows the area, the number and the category of the protected area within each country.
(Source: UNEP-WCMC 2003)

the controls previously imposed through traditional systems. This has led to problems of overexploitation and pollution, although these are highly localised and there are vast areas of reefs that are in very good condition. Marine protected areas are few, but the oldest in the Pacific, Palolo Deep National Marine Reserve, was established in 1974 in Apia, Samoa (Skelton 2000).

Sulu et al. (2002) state that the coral reefs of the southwest Pacific are generally in good condition, but continue to degrade as a result of human pressures, and because of two widespread coral bleaching events in 2000 and 2002. In 2000, coral mortality in Fiji reached 40% (Sulu et al. 2002).

Mangroves

Mangrove forests are prevalent in estuarine areas of the high islands of the region, but poorly developed or scarce on atolls. Scott (1993) has prepared a directory of Pacific Island wetlands, while their distribution and ecology are reported in Woodroffe (1987). Traditional cultures have utilised mangroves for generations for firewood and construction, and have long recognised the importance of mangroves as nurseries for crustaceans and some lagoon fishes. Mangrove species biodiversity declines from west to east and the most extensive mangrove habitats are found in Papua New Guinea, Solomon Islands and Fiji, with the natural eastern-most limit in American Samoa. Mangroves are absent from Wallis and Futuna, Tokelau and the Phoenix and Line Islands (Kiribati).

Seagrasses

Seagrasses are common throughout much of the Pacific Islands region (Wells & Jenkins 1988). They stabilise sediments and contribute to the detrital cycle of shallow lagoons. They are an important habitat for a number of commercially important species, and provide food for dugongs and turtles. The seagrass beds of Fiji are an important foraging area for sea turtles.

Socio-economic characteristics

The Pacific Islands have been inhabited for approximately 3 500 years (Fiji) and for approximately 2 500 years or less in Polynesian countries (e.g. Samoa). Colonisation extends back no more than 200 years. Habitat and community modification were significant in pre-colonial times, since Pacific cultures practiced agriculture and strongly modified their environment in order to establish their gardens. A percentage of the environment was, therefore, already altered prior to the arrival of

European colonists. There is evidence to suggest, however, that the relatively small populations had a lesser impact on coral reefs and lagoons, even though there is evidence that some of the stocks of fishes and invertebrates had been overfished prior to European contact (Table 2). The present day situation with regard to habitat modification and destruction is a result of approximately 200 years of impact by human populations, added to that already conducted by indigenous peoples pre-contact. These impacts include deforestation, depletion of fish stocks, destruction of habitats (especially mangroves and other vulnerable coastal ecosystems) through urbanisation, industry and infrastructure development, waste disposal, pollution, mining, and agriculture. Freshwater catchments are almost completely impacted by human activities and are no longer in their natural state, and areas of pristine forest and other habitats are becoming scarce. Government policies, whether those of the colonists or of the current regimes following independence, have played a key role leading to the current situation.

Population

The current population of the region is approximately 8.3 million (CIA World Factbook 2003), and Papua New Guinea accounts for more than 63%. Population densities range from just over 8 persons per km^2 for Niue to 599 persons per km^2 for Nauru. If the "most populous islands" are considered, the figures rise to over 100 persons per km^2 for four islands, over 200 for 3 islands, and 421 for Koror in Palau, 757 for Funafuti in Tuvalu, 1 179 for Majuro in the Marshall Islands, and 2 190 for Tarawa in Kiribati. The estimated population for Betio Islet of Tarawa Atoll was 40 000 in the year 2000, which gives it a population density rivalling those of Hong Kong and Singapore. If we consider Ebeye, one of some 90 islets comprising Kwajalein Atoll in the Marshall Islands, to which people were relocated by the U.S. military to free the atoll's lagoon for intercontinental ballistic missile testing, the population density increases to over 25 000 per km^2!

There are three racial and sub-cultural groupings, which are referred to as Melanesia, Micronesia and Polynesia (Figure 1). The Melanesian islands are all relatively large archipelagos and include Papua New Guinea, Solomon Islands, Vanuatu and New Caledonia, with Fiji lying half way between Melanesia to the west and the Polynesian islands of the central Pacific. Polynesia includes American Samoa, the Cook Islands, French Polynesia, Niue, Pitcairn, Tokelau, Tonga, Tuvalu, Wallis and Futuna and Samoa. Micronesia lies mainly close to or north of the equator, and includes the Federated States of Micronesia (Yap, Chuuk, Pohnpei and Kosrae), the Northern Mariana Islands, Guam, Marshall Islands, Nauru, Palau and Kiribati.

The three cultural groups have distinctive traditions and lifestyles that have prevailed to varying degrees to modern times. They have

Table 2 Summary of results of analysis of fish bone and mollusc shell assemblages in Pacific Island archaeological sites.

Location	Time period (years ago)	Comments	Source
Matenkupum (New Ireland, Papua New Guinea)	32 0000	Earliest evidence of human capture of marine fish in world. Site contains bones and shell fragments of reef fish and molluscs. Capture probably by reef gleaning, stone fish traps or weirs, and with spears.	Allen et al. 1989
Tongatapu (Tonga)	3 500-2 000	Initial heavy exploitation of bivalve molluscs (*Anadara* spp. and *Gafrarium* spp.) by early colonisers, followed by decline in *Anadara* spp. due to a combination of fishing pressure and environmental effects. Mortality curves for *Gafrarium* reflect increasing fishing pressure on population with decrease in average size (and age) in population.	Spennemann 1987
Mangaia (Cook Islands)	980-330	Significant increase in frequency of molluscan remains at about 500 years ago. Average size of gastropod *Turbo setosus* decreased by 50% between the earliest layers in the sequence and those in later years.	Kirch et al. 1995, Butler 1993
Tikopia (Solomon Islands)	2 900-200	Ark shells and other gastropods are major source of animal protein during initial period of colonisation. Mollusc populations reduced through fishing and environmental change, followed by diversification of food base through agriculture.	Kirch & Yen 1982
Pari (southeast Papua New Guinea)	2 000-Present	Gastropod and bivalve molluscs in shell middens reflect exploitation pressure with shift through time, with decrease in average size (and age) in population.	Swadling 1977
Mussau (northern Papua New Guinea)	3 500-350	Composition of fish bone assemblages with time remains relatively constant, with landings dominated chiefly by lethrinids, scarids and serranids.	Kirch et al. 1991
Santa Cruz Islands (Solomon Islands)	3 200-2 600	Gastropod and bivalve molluscs in shell middens reflect exploitation pressure with shift through time, with decrease in average size (and age) in population.	Swadling 1986
Niutoputapu (Tonga)	2 800-200	Fish bone assemblages from excavations show long-term exploitation of reef and lagoon species, similar to contemporary fishing patterns.	Kirch & Dye 1979, Kirch 1988
Kapingamarangi and Nukuoro (Caroline Islands)	1 050-500	Fish bone assemblages reflect importance of reef and lagoon fish as staple animal protein, despite cultural importance of pelagic fish such as rainbow runner (*Elegatis bipinnulatis*).	Leach & Davidson 1988
Aitutaki (Cook Islands)	2 000-1 000	Change in shell hook manufacture from pearl oyster shell (*Pinctada margaritifera*) to turban shell (*Turbo setosus*) with time due to breakdown in inter-island communication and trade. Reliance on more fragile *Turbo* hooks reflected in greater exploitation of smaller lagoon fishes .	Allen 1992
Palau	1 300-100	Fish bone assemblages suggest continuity in reef fish composition and fishing practices during pre-contact period.	Masse 1986
Mussau (Papua New Guinea) Main reef Is & Tikopia, (Solomon Islands) Lakeba (Fiji) Niutoputapu (Tonga)	3 500-350	Comparison of fish bone assemblages suggests greater reliance on line fishing for reef carnivores in West Pacific compared to net and spear fishing for reef herbivores/omnivores in East. Differences may possibly reflect greater fishing pressure in east with reduction of reef carnivore populations.	Butler 1994

(Source: adopted from Dalzell & Adams 1996)

in common chiefly systems (mostly patriarchal, but some matriarchal), customary ownership of land, coast and resources, and complex social structures within communities. In the post-colonial era, migration, rapid population growth, urbanisation and urban drift, the introduction of western culture and religions, the adoption of westernised governance and legal systems, and the introduction of the cash economy, have substantially eroded many of these traditions. There has been a substantial loss of traditional knowledge, and many of the customary systems that were in place and resulted in conservation of resources have been severely compromised (South et al. 1994). There is, however, a growing recognition of the value of traditional systems and the realisation that these are best used together with modern systems of resource management in a co-management environment (Veitayaki in South et al. 1994).

Economy

The Pacific Island states and territories are among the poorest nations, and are strongly dependent on their renewable and non-renewable resources for their economic survival. The cash economy has become a major driving force: populations' desire living standards and lifestyles comparable to those they learn about from developed nations, yet, with the exception of a privileged few, they do not have the resources to bring this about. Modern technology is brought into these countries through many different programmes, but oftentimes the technology is inappropriate for small islands. The island states are overwhelmed by the possibility that global change can result in a total loss of their territories (such as atoll states like Tuvalu and Kiribati); they have become effective global advocates of the importance of mitigating against those factors that are causing climate change and sea-level rise.

Many Pacific Island cultures maintain much of their traditional lifestyles and value their traditions, yet they are afflicted by many of the same problems as other parts of the world, such as an alarming increase in the rate of HIV infections and sexually transmitted diseases, and by non-communicable lifestyle diseases such as diabetes mellitus. Religion has a major influence on the lives of Pacific peoples, and the church can be very effective in helping to deal with community-driven concerns. Yet religion and cultural traditions have also proved to be obstacles in areas such as birth control and awareness raising about HIV, since human sexual issues may not be discussed either within the family or within the community, leading to ignorance, early pregnancies and high birth rates.

Apart from Papua New Guinea, the most far-reaching constraint on development in the region is the small size of the countries, and their remoteness from the main trading centres. GDP is very low for the smallest nations, well below 500 USD per capita per year (Table 1). Those with the highest GDP are states still under colonial rule, such as French Polynesia and Guam. The countries are also separated from one another by vast areas of deep ocean, resulting in isolation and high transportation costs. In addition, natural disasters such as cyclones, floods, tsunamis and droughts plague many of the countries, and these problems are exacerbated by global problems of climate change and sea level rise. These phenomena threaten entire countries such as the low-lying atolls countries of Kiribati and Tuvalu, and the largely coastal populations of the high islands (South & Veitayaki 1999).

In terms of current level of development and potential for modern economic development, although some of the larger island groups with significant mineral, forestry, fisheries and agricultural land resources have some potential, most Pacific Island states and territories and smaller outer islands and isolated rural communities do not. Because of their small size, geographic isolation and extremely limited natural resources the options for modern economic development are extremely limited. Consequently, most island countries, territories and local communities will, for the foreseeable future, have to depend on the sustainable use of their local resources as a basis for their survival and development. In this respect, it is stressed that the Pacific Island region is unique in that most of the islands of the region are inhabited by indigenous peoples that have close links with, and great cultural, economic and spiritual dependence on, their island terrestrial and marine environment. In most cases, these indigenous people are the owners and users of these resources and ultimately control decisions related to their conservation and sustainable use. This situation contrasts with other archipelagic regions of the world, such as those in the Indian Ocean and the Caribbean Sea, and continental areas where there is more private or public land.

The South Pacific is one of the most heavily aid-assisted regions in the world (Fairbairn 1994) with an estimated annual total of 1 100 million USD, or 170 USD per capita per year (1990 estimate). Approximately 90% of the aid is bi-lateral with Australia, France, Japan, the European Community and the United States of America contributing the greatest proportion. With decolonisation and shifting allegiances of some of the newly independent states from their previous colonial masters, links are being strengthened with Asia and increasing amounts of aid is being provided from Japan, the People's Republic of China, Korea and Taiwan. In addition, private sector investments from the Association of Southeast Asian Nation (ASEAN) countries, particularly Malaysia, are changing the face of the consumer and investments markets in the region (South & Veitayaki 1999).

Environmental issues are now recognised as critical in the promotion of sustainable growth and an improved quality of life. As stated by South and Veitayaki (1999): "Pacific Island environments are fragile and highly vulnerable. There is a need to incorporate integrated environmental principles in planning at all levels, specifically related to the forestry, mineral resources, agricultural and fishery sectors, but equally importantly in urban planning, waste disposal and the tourism industry."

Government and policies

Economic issues often override environmental concerns in government planning and policies. There is a trend towards recognition of the need for more integrated planning, to comply with global conventions and agreements through the development of appropriate national laws and regulations, and a number of Pacific Island countries have drafted or have even enacted (e.g. in Cook Islands) new environmental laws and policies which recognise these needs (e.g. the Fiji Government's draft Sustainable Development Bill).

These are, however, the exceptions: the sustainability ethic is widely spoken about, but in reality, it is an almost unachievable goal given the financial and socio-economic constraints under which governments have to work. Small populations, inadequate funding, lack of the necessary human resources and lack of political will are all contributing to the current situation that is leading to more and more unregulated destruction and modification of habitats and ecosystems in the Pacific Islands. There is also a long-standing dependency on donors (who are often the same countries that were once colonial governors), and donor policies have in themselves been strong external root causes. There has also been, regrettably, a culture of corruption in some countries where government or private sector leaders have compromised standards or ethics in return for under the table deals with outsiders willing to fund major developments. In some cases, such as the enormous mahogany resources in Fiji, disagreements between land owners, government and private industry have led to significant unrest, and were one of the factors leading to the 2000 coup in Fiji.

At the community level, traditional systems are breaking down with the change to the cash economy, urbanisation and the desire of the people to have a lifestyle comparable to that they witness daily through the media. This desire percolates throughout society to the government level, where ministers of even the smallest countries aspire to the trappings of ministers in developed countries. This has led to a considerable degree of corruption in some countries, and the breakdown of society and the economy such as happened recently in the Solomon Islands. Some segments of society remain disenfranchised, especially women and youth, and decision making and planning may take place without reference to those who are among the most important providers of food for their families. Traditional marine tenure has also been a factor in the potential for the development of Marine Protected Areas (MPAs) in some countries, and was discussed in detail in South et al. (1994). Where the initiatives come from the communities themselves, progress is likely to be made in this area. One trigger to the realisation by communities of the need for MPAs is when fish and invertebrate stocks are seriously depleted. Fiji's Locally Managed Marine Area (FLMMA) project is an excellent example of how progress is likely to be made (Tawake 2004).

Politically, the South Pacific Island countries and territories are all members of the South Pacific Conference that was first convened in 1947, and which includes the governments of New Zealand, Australia and the United States (Dalzell et al. 1996, South & Veitayaki 1999). Fourteen independent states, with the addition of New Zealand and Australia, are members of the South Pacific Forum, established in 1971 and headquartered in Suva, Fiji.

Organisationally, the South Pacific region has been frequently used as a model within the Regional Seas programme. South and Veitayaki (1999) provided a detailed review of regional approaches to workable arrangements in the context of global initiatives in the South Pacific. Inter-governmental bodies oversee regional programmes on a sectoral basis:

- Forum Fisheries Agency: oceanic fisheries;
- Secretariat for the Pacific Community: coastal fisheries and socio-economic programmes;
- South Pacific Applied Geoscience Commission: non-living resources; boundary delimitation;
- South Pacific Regional Environment Programme: environmental issues;
- Regional Seas Programme.

These inter-governmental agencies use a consensus approach to decision making (often referred to as the "Pacific Way"). As a result of colonisation, countries in the region have adopted legal systems based on those of the British, French or United States; as a result, there is a lack of uniformity among legal systems within the region. Heathcote (1997) addresses the resulting problems experienced under Maritime Law in Forum countries, and has recommended ways of standardising law in at least this sector. Traditional law also applies in some countries, and in Samoa, for example, a system of village rules governing fisheries management has been established (Fa'asili & King 1997). In Fiji, there are moves to legally recognise the qoliqoli (fishing area) owners and customary owners of foreshore areas (Aqorau 2003).

Legal framework and conventions

International Waters Strategic Action Programme

The Strategic Action Programme for the International Waters of the Pacific Small Island Developing States was developed through an extensive consultative review (SPREP 2001a). This review comprised national committees and formation of a regional task force, whose ultimate task was to prepare documentation for SPREP's (South Pacific Regional Environment Programme) International Waters Project, which commenced in 2001. The International Waters (IW) Project is tackling specific issues within the Strategic Action Plan, and a total of 14 demonstration projects are under development throughout the region. Policy issues are paramount in the International Waters Strategic Action Plan. Clearly, there would be little to be gained from a repeat of this exercise, which is funded by the Global Environment Facility (GEF) and the Australian Government for a total of 20 million USD over five years, when the GIWA budget for the region was 50 000 USD.

The Strategic Action Plan identified three priority transboundary concerns related to international waters: (i) degradation of quality; (ii) degradation of critical habitats; and (iii) Unsustainable use of living and non-living resources. These concerns closely relate to those identified under GIWA. SPREP summarised the principal issues needed to address priority environmental concerns among Pacific Island countries (Table 3).

Table 3 Strategic Action Plan to address environmental concerns in Pacific Islands countries.

Goal	To achieve global benefit by developing and implementing measures to conserve, sustainably manage and restore coastal and oceanic resources in the Pacific Region (Integrated sustainable development and management of International Waters)
Priority concerns	Degradation of water quality: - Degradation of associated critical habitats - Unsustainable use of resources
Imminent threats	Pollution from land-based activities: - Modification of critical habitats - Unsustainable exploitation of resources
Ultimate root	Management deficiencies - Governance - Understanding
Solutions	- Integrated coastal and watershed management - Oceanic fisheries management
Activity areas (coastal)	- Improved waste management - Better water quality - Sustainable fisheries - Effective marine protected areas
Activity areas (oceanic)	- Sustainable ocean fisheries - Improved national and regional management capability - Stock and by-catch monitoring and research - Enhanced national and regional management links
Targeted actions	- Management/institutional strengthening - Capacity building/institutional strengthening - Awareness/Education - Research/information for decision making - Investment

(Source: SPREP 2001a)

Pacific Islands Regional Ocean Policy

In 2002, the South Pacific region approved a Pacific Islands Regional Ocean Policy (PIROP). The Ocean Policy was developed on behalf of the Forum Secretariat by the Council of Regional Organisations of the Pacific (CROP) Marine Sector Working Group. Several members of the GIWA Task team were instrumental in the development of PIROP. A Framework for Integrated Strategic Action (ISA) was drafted during the Pacific Islands Regional Ocean Forum (PIROF) held in Suva, Fiji in February 2004, by the more than 200 national, regional and international delegates attending the Forum. This is the most recent example of the success of the regional approach to ocean issues, and will lead to establishment of priorities and actions relating to ocean policy. The PIROP will also provide a general framework to assist national governments in the development of their own policies.

The UN framework

Within the framework of the various UN conventions and agreements to which many of the countries are signatory, many national activities have been initiated as part of the reporting requirements of such conventions and agreements. In addition, a number of countries have created new departments, divisions or ministries, charged with overseeing environmental issues, again in response to UN conventions and agreements, such as Agenda 21, Chapter 17 which is concerned with coastal issues. With respect to the Exclusive Economic Zones (EEZs) of the Pacific Island nations, many agreements and regional initiatives have been agreed to, facilitated by the Forum Fisheries Agency and the Secretariat of the Pacific Community, under their oceanic programme. Their most recent and important achievement has been agreement to establish a new commission, charged with management and conservation of highly migratory fish stocks such as tuna. In 2003, Pacific Island representatives attended a meeting sponsored by Environment Australia, to discuss the management and conservation of biodiversity on the high seas, i.e. those areas of ocean not included within EEZs. Pacific Island nations are represented in various ways within the United Nations, and through their advocacy have raised the profile of issues affecting island states globally. Finally, regional universities and international NGOs have played an increasingly important role in the Pacific Islands, especially at the community level.

World Summit on Sustainable Development

At the World Summit on Sustainable Development in Johannesburg 2002, the Pacific Islands region proposed a series of Type II Initiatives which address all of the policy issues referred to in this report. These initiatives identified many partners required for their implementation, including donors and developed countries. It is to be hoped that these initiatives will develop to the overall advantage of the region.

Assessment

Table 4 Scoring table for the Pacific Islands region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

IMPACT 0 No known impacts
IMPACT 1 Slight impacts
IMPACT 2 Moderate impacts
IMPACT 3 Severe impacts

The arrow indicates the likely direction of future changes.

↗ Increased impact
→ No changes
↘ Decreased impact

Pacific Islands	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.7* ↗	2.0 →	2.0 →	1.0 →	**1.7**	5
Modification of stream flow	1					
Pollution of existing supplies	2					
Changes in the water table	2					
Pollution	2.2* →	1.0 ↗	2.0 →	1.0 →	**1.7**	4
Microbiological pollution	2					
Eutrophication	1					
Chemical	2					
Suspended solids	2					
Solid waste	3					
Thermal	1					
Radionuclide	3					
Spills	1					
Habitat and community modification	2.5* ↗	2.0 →	2.0 →	2.0 ↘	**1.9**	3
Loss of ecosystems	2					
Modification of ecosystems	3					
Unsustainable exploitation of fish	2.3* ↗	2.0 →	2.0 ↗	2.0 →	**2.2**	2
Overexploitation	3					
Excessive by-catch and discards	3					
Destructive fishing practices	2					
Decreased viability of stock	1.5					
Impact on biological and genetic diversity	2					
Global change	2.6* ↗	3.0 ↗	2.0 ↗	2.0 ↗	**2.7**	1
Changes in hydrological cycle	2					
Sea level change	3					
Increased UV-B radiation	1.5					
Changes in ocean CO_2 source/sink function	1.5					
Increase in sea surface temperature	3					

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 4. Detailed scoring information is provided in Annex II of this report.

Freshwater shortage

Freshwater shortage is a problem in the Pacific Islands, especially among the atoll states, and is associated with changes in the hydrological cycle resulting from global change as well as reductions in stream flow, pollution of existing supplies and changes in the water table as a result of human activities (WHO/UNICEF 2000). A summary of water resources and supplies in selected countries in provided in Table 5.

Access to potable water is very uneven across the region, ranging from the lowest percentage in Papua New Guinea (24%) to 100% in Nauru, Niue and Samoa (Table 5) (WHO/UNICEF 2000). Although access may be relatively high in some of the atoll countries (Kiribati 76%, Tuvalu 95%), the supplies are highly vulnerable to climate (annual and seasonal fluctuations in the amount of rainfall; El Niño and La Niña effects) and changes in sea level, leading to salt incursion in freshwater lenses. Only a few of the larger high islands (Papua New Guinea, Solomon Islands, Fiji) have significant freshwater bodies (lakes and rivers), but catchments are poorly managed and subject to erosion because of human activities such as forestry, clear cutting, agriculture, horticulture, construction and

Table 5 Summary of water resources and water supplies in selected countries.

Country	Main water resources	Access to safe water (% of population)*	Water supply coverage (% of population)**
Cook Islands	SW, GW, RW	95	100
Federated States of Micronesia	SW, GW, RW	44	ND
Fiji	SW, GW, RW, D (tourist resort only)	77	47
Kiribati	GW, RW, D (limited)	44*	47
Marshall Islands	RW (from airport catchment and buildings), GW, D (emergency)	82	ND
Nauru	D (regular use), RW, GW (limited)	100	ND
Niue	GW, RW	100	100
Palau	SW, GW, RW	86	79
Papua New Guinea	SW, GW, RW	10**	42
Samoa	SW, GW, RW	50-70*	99
Solomon Islands	SW, GW, RW	64	71
Tonga	GW, RW	95	100
Tuvalu	RW (primary) GW (limited)	85	100
Vanuatu	SW, GW, RW	87	88

Note: SW = Surface water; GW = Groundwater; RW = Rainwater; D = Desalination; ND = No Data.
*(Source: WHO/UNICEF 2000, * Hoegh-Guldberg et al. 2000, ** Lauerman 1997)*

mining. Pollution of water supplies is a growing problem especially in urban areas or along narrow coastal plains which are impacted by run-off, high levels of sedimentation, mining (Papua New Guinea, Fiji, New Caledonia), herbicides and fertilisers (e.g. sugar-cane growing areas of Fiji), industry, and by a universal lack of proper sewage treatment. The socio-economic impacts are becoming critical, driven by increasing population (and higher demand on water supplies), health risks from increasing bacterial levels, inadequate or out-dated water distribution, treatment and drainage systems, and inadequate planning and management of catchments.

Environmental impacts

Modification of stream flow

Owing to the general absence of large catchment areas and major freshwater bodies in the Pacific Islands region, modification of stream flow exerts only a slight impact at a regional scale. However, changes in stream flow have occurred in some of the larger catchments, particularly on Fiji where natural changes in the amount of precipitation, coupled with changes in land use for forestry and agriculture, coastal and urban developments and the construction of dams to generate hydroelectricity have produced considerable fluctuations in stream flow. For example, the average stream flow in the Ba River varies between 10 m^3/s in the dry season and 60 m^3/s in the wet season. However, the increased water-uptake that has occurred through the replacement of 60 000 ha of natural grassland with rapidly growing pine forests for timber has caused a decline in dry season flows by 50-60% which has jeopardised the operation of Monasavu hydroelectric dam (FAO 1987) and resulted in significant drinking water shortages during the dry season (Terry & Raj 1998). These declines have been exacerbated by large-scale climatic fluctuations, such as El Niño, which, in 1997/1998 resulted in 20-50% less than average rainfall in Fiji causing a drought that affected the growth of forests, caused fires, destroyed 25% of the sugar cane crop and 50% of the vegetable crop and affected 263 455 people (Kaloumaira 2000). Conversely, in the Rewa River Basin conversion of natural vegetation for cultivation of cash crops such as vegetables and ginger has resulted in considerable erosion, sedimentation and flooding (Anon. 2003). For additional details, see the Causal chain analysis of modification of stream flow in the Rewa and Ba River basins below.

Pollution of existing supplies

There is a notable lack of documentation on the issue of pollution of surface and groundwater supplies throughout the entire region. Pollution of existing supplies of freshwater on large high islands with relatively large human populations, such as PNG and Fiji, is moderate but is offset by annual rainfalls that exceed 3 000 mm per year. On smaller low-lying coral islands, natural supplies are very limited and contamination of surface waters by human and animal waste, and by improper disposal of solid wastes, poses a greater threat, even when the size of human populations is much smaller. On atolls, where the main supply of water is from a shallow lens up to 30 m thick, there is a high risk of bacterial pollution from high-density populations, or from salt intrusion during periods of overuse or excessive drawdown of the supply, such as on Tarawa Atoll in Kiribati.

Changes in the water table

Reduced rates of replenishment and salinisation of groundwater over regionally significant sub-areas exert moderate impacts on the region. Subterranean lenses of freshwater are the primary sources of drinking water for many inhabitants of small islands, particularly atolls such as Tarawa in Kiribati. Burgeoning human populations are placing extreme pressure on these limited resources often leading to shortages of drinking water. These problems are often exacerbated by dysfunctional distribution systems and storage facilities or unreliable natural replenishment from rainfall. For example, at Tarawa Atoll in Kiribati, the Bonriki lens supplies 75% of the freshwater available to 35 000 inhabitants (Metai 2002). The lens is able to support a pumping capacity of 1 000 m^3/day but if rainfall declines by 25% and the rate of water extraction is not adjusted, the thickness of the lens, which is normally about 30 m (Falkland 1992), is reduced by 64% (Alan & Falkland,

1997). In order to maintain supplies of freshwater to people living on the island during periods of reduced precipitation, authorities have been forced to impose restrictions on water use. In addition, the expansion of coconut cultivation and excessive pumping by the agricultural sector has contributed to changes in the level of the water table which has allowed saltwater to contaminate groundwater resources in most atoll countries in the region and in some low-lying coastal areas of many of the high islands in Melanesia. For additional details, see the Causal chain analysis of changes in the Bonriki freshwater lens below.

Socio-economic impacts

Economic impacts

The loss of potable water supplies was considered severe in atolls because of overuse, and salinisation during droughts; and of increasing severity in coastal areas of larger islands where coastal erosion is impacting the vulnerable coastal plains on which most of the population live. The loss of agricultural use was seen as a major impact in the region, since most Pacific Island agriculture occurs on the coastal plains, which are increasingly affected by seawater flooding and erosion during exceptional high tides (Nunn 1990, Terry et al. 2001, 2002). In the city of Suva, capital of Fiji, there are increasing disruptions to municipal water supplies, which are, in part, due to failure of old piping systems, but also because of rapidly increasing population and demand on the water supply. There is a need for better planning and for the upgrading of water supply systems, which are very costly and require aid assistance (Members of the GIWA Task team pers. comm.).

Health impacts

The loss of potable water supplies has caused health impacts in the region demonstrated by increasing rates of intestinal and water-borne disorders such as cholera, dysentery and hepatitis, especially in, but not restricted to, the atoll countries (Tebano 1984, 1992). Most segments of society are vulnerable, but especially children and elderly people. The Secretariat for the Pacific Community (SPC) maintains a database on health and related issues (SPC 2003).

The impacts of long-term nuclear testing in Marshall Islands continue, with enhanced levels of cancer in those exposed to the radiation; unsafe water supplies and residual radiation continue to prevent return of residents to these islands. A chronology of events since the first evacuation from Bikini Atoll in March 1946 until 1996 is provided in the Republic of the Marshall Islands (RMI) website (RMI 1996), which also includes a selected bibliography. In December 1995, the Nuclear Claims Tribunal awarded 43.2 million USD, nearly its entire fund, to 1 196 claimants for 1 311 illnesses. The following year the Tribunal estimated that a further100 million USD in personal injury claims would be needed by 2001.

Other social and community impacts

The impacts resulting from the inability to engage in recreational activities such as fishing, and the decline in aesthetic value resulting from the loss or destruction of coastal habitats such as mangrove forests were considered significant. Migration from rural and coastal regions to urban areas has changed the traditional patterns of subsistence fishing and gardening to those of the cash economy and urban living, putting pressure on already limited locally produced food supplies, and leading to a greater dependence on imported foods. Migration due to lack of drinking water and relocation of agriculture due to drought or coastal salinisation are severe, especially on atolls. In Kiribati, the large majority of the residents on Tarawa Atoll (>25 000) have migrated from outer islands.

Conclusions and future outlook

The finiteness of water supplies, and their vulnerability to human impacts, are long-term and will need to be addressed by Pacific Island nations if their quality of life, health and food security are to be maintained. The prognosis is that the existing problems will continue to worsen in the coming years unless appropriate actions are taken. There is a need for continued and enhanced awareness-raising among stakeholders and decision-makers on the proper management and conservation of water supplies and catchments, since bad decisions or mismanagement will only exacerbate the underlying fact that potable water and its availability have long governed, and will continue to govern migration and settlement in the Pacific Islands region. Rapidly increasing populations and urbanisation of the Pacific countries, in combination with global change, will have increasing impacts on water supplies for the indefinite future. The region's recognition of the challenges facing them in sustainable water management through their adoption of the Pacific Regional Action Plan on Sustainable Water Management (SOPAC 2002), together with the WSSD Type II Initiative on Sustainable Water Management, offer the region's best chance of dealing with the immediate and future challenges, but significant resources will be needed to address this and it is not yet clear whether these resources will be available in the necessary time-frame.

Pollution

Most forms of pollution are localised and not regional or transboundary in nature. Health risks from microbiological pollution are moderate to severe close to urban and industrial areas, but are low or negligible in more remote or unpopulated areas. Eutrophication of lagoonal and near-shore habitats is widespread close to all populated areas, as a

result of urban (especially sewage), agricultural and industrial run-off, or discharges from sugar cane crushing mills (Fiji), and fish processing plants (Fiji, Solomon Islands, American Samoa). Chemical pollution is largely unregulated and is at extreme levels at some sites (e.g. tri-butyl tin in the Suva Lagoon, Fiji). Other heavy metals and toxic discharges are associated with mining (Papua New Guinea, New Caledonia, Fiji) and industries such as paint or battery manufacturing (Fiji). Suspended solids are increasingly affecting the health and biodiversity of coral reefs, and are linked to poor land use practices including deforestation (Solomon Islands, Fiji, Papua New Guinea), mining (New Caledonia, Papua New Guinea, Fiji), road construction, causeway construction (Kiribati) and tourism infrastructure development.

Solid waste disposal is a universal problem, and litter is a prevalent eyesore in most populated areas; it is a serious problem for human health and the environment, and discarded plastic items are, for example, a major hazard for sea turtles and seabirds. Approximately 25% of the waste is non-biodegradable and thus poses a serious long-term threat.

A regionally significant problem is the long-term pollution risk from discarded military waste. The 857 sunken World War II wrecks present in the region (mostly in Papua New Guinea, Solomon Islands and Micronesia) are a lingering source of petrochemical and other toxic compounds that can leak onto vulnerable coral reefs (see also Habitat and community modification). Their disposal will be a costly problem that will have to be dealt with on a case-by-case basis. The effects of extensive nuclear testing in the region represent a long-term radionuclide pollution problem (Marshall Islands, Kiribati and French Polynesia). Major oil spills have not been a serious threat so far, but small, localised spills or leakages are common in ports and harbours, and close to urban centres. Shipping-related oil and ballast discharges are poorly documented and are probably prevalent, although visible impacts of oil on reefs or beaches are negligible.

The consequences of pollution have a significant impact on the health of the people. They also affect the health of inshore ecosystems, especially coral reefs, mangroves and lagoons. Ciguatera fish poisoning is widespread in all the atoll countries, and its incidence is exacerbated in those areas impacted by pollution (including eutrophication and increased sedimentation). Nuclear testing and the subsequent radionuclide pollution have caused major disruptions and relocation of entire communities, and escalating costs of compensation for health-related problems. The community and social impacts from pollution are hard to measure, and there is a need for awareness-raising at all levels on how changes in life-style and ethics can raise consciousness about the effects of pollution on people's lives.

Environmental impacts

Microbiological

In the Suva area (Fiji) coliform bacteria counts well above World Health Organization (WHO) limits have been recorded over the years and are likely to have also occurred in other urbanised areas throughout the region, although data are lacking in many instances. It is interesting that in Suva, at least, no public warnings are posted in swimming areas with known high coliform counts and, as a consequence, many people, especially children, are exposed to risk. Since the Suva Lagoon is an area of high fishing intensity, authorities would be faced with a difficult decision regarding banning of water activities.

Eutrophication

Localised eutrophication resulting from agricultural/urban run-off and untreated sewage exerts only a slight impact on the regional scale, although the increases in abundance of epiphytic algae and macro-algae along the coasts of most islands is often obscured by natural seasonal increases in the abundance of *Entermorpha, Chaetomorpha* and *Cladophora* during the wet season.

Chemical

High concentrations of chemical contaminants, such as tri-butyl tin (TBT) and heavy metals at sites like the Suva Lagoon (Gangaiya et al. 2001), large-scale use of pesticides in agriculture and forestry, oil from machinery and increased logging and mining activities near waterways (e.g. Solomon Islands, New Caledonia and PNG) and effluents from sugar cane mills (as in Lautoka, Fiji) exert moderate impacts on the region. Notable examples of environmental impacts are: imposex in molluscs caused by elevated levels of TBT (Rilov et al. 2000), leakages

Table 6 Characteristics of solid waste in selected countries in the Pacific Islands region, 1990-1994.

	Honiara (Solomon Islands)	Nuku'alofa (Tonga)	Lautoka (Fiji Islands)	Port Vila (Vanuatu)	Average
Average bulk density (kg/m^3)	209	159	169	158	174
Generation rate (kg/capita/day)	0.62	0.82	0.94	0.65	0.76
Waste classification (% by wet weight)					
Plastic	16.8	5.2	8.1	7.7	9.5
Glass	4.5	3.3	2.7	3.3	3.5
Metals	6.1	8	3.2	3.6	5.2
Biodegradable	64.6	47.2	67.8	71	62.7
Textiles	1.8	3.7	3	1.6	2.5
Potentially hazardous	0.1	<1	0.2	0.7	0.5
Construction and demolition	0.1	1	0	0.7	0.5
Other	0	0.3	0.2	0	0.1

(Source: Raj 2000)

Figure 3 Example of solid waste disposal problem.
(Photo: G.R. South)

from e.g. mine tailings leading to fish death, and impacts on marine life from oil leakages from ships.

Suspended solids

There are localised and moderate impacts on water bodies due to increased turbidity, and there is extensive evidence of changes in sedimentation and/or erosion rates as well as changes in biodiversity due to suspended solids (Members of the GIWA Task team pers. comm.). For example, deforestation in PNG, Solomon Islands and Fiji has promoted heavy run-off during major rainfall events and, in turn, has caused increased turbidity. Modification of coastal areas, such as the Denarau Island development in Fiji and the construction of causeways in Kiribati, have caused changes in erosion rates and patterns in these areas. In addition, coral reefs near Savusavu (Vanua Levu Island, Fiji) have been smothered by deposits from gold mine tailings, leading to a significant deterioration in coral health (Schläppy, pers. comm.) and by urban run-off in Majuro (Marshall Islands) (South unpublished) and Honiara, Solomon Islands. Further, wastewater run-off from tuna processing plant has caused eutrophication effects on reefs near Ovalau, Fiji (Lovell pers. comm.) and Pago Pago, American Samoa (Skelton unpublished). The general decline and transformation of some reefs to algal reefs along the Coral Coast of Viti Levu Island, Fiji has been attributed to the impacts of hotel development along that coast, and this currently under investigation by the University of the South Pacific's Institute of Applied Science.

Solid wastes

Litter is a universal problem amongst all the islands (Table 6), especially in urban areas, which have resulted in some areas, such as the shoreline surrounding the Lami Dump in Fiji, being condemned for safety reasons. The Lami Dump, which is situated close to the city of Suva, is a notorious source of many toxic chemicals, including heavy metals that are constantly leaching into the lagoon, presenting a health hazard to local people who continue to fish nearby. The problem of solid waste is further exemplified by the shoreline of Nauru which appears 'blue-green' as a result of the accumulation of Foster's and Victoria Bitter beer cans. Littering of the coastal area is an eyesore in all of the countries, which is a pity given that proper recycling is not that complicated to solve. Discarded military waste is also a problem in some countries (Figure 3). Entanglement of turtles and marine birds in discarded fishing nets, and death of turtles and birds caused by ingestion of plastic waste, is also an added factor.

Thermal

The presence of thermal discharges was noted in some areas, such as Savusavu Bay from a gold mine, and Levuka, Ovalau Island, Fiji Islands from a tuna processing plant where an outbreak of *Ulva lactuca*, a green bladed alga that had not been recorded from Fiji, was observed (the *Ulva* outbreak might be equally attributable to enhanced nutrients). At Savusavu, a reduction in coral cover attributable to heavy sediment loading, and an increase in benthic macroalgae, was observed during unpublished surveys. Although the altered biodiversity, especially reduction in the numbers of scleractinian coral species is moderate (Lovell pers. comm.), it does not occur at the region-wide scale.

Radionuclide

Past and recent nuclear testings undertaken by France and the United States on islands such as Moruroa and the Marshall Islands (Bikini and Kwajalein atolls) have caused severe impacts on the region (Figure 4). The more than 180 atmospheric and underwater tests at Moruroa and Fangataufa atolls have dispersed into the environment or have created crude underground nuclear waste dumps of hundreds of kilograms of plutonium and other highly radioactive fission products (Greenpeace 1995). There are reports that some of the coral framework of reefs at Mururoa may have cracked following nuclear tests, although the significance of this in biological or ecological terms needs further documentation. Cousteau concluded in a 1987 Mission Report (as cited in Greenpeace 1995) that nuclear testing had caused accelerated and premature aging of the atoll: "The tests conducted under the lagoon still produce fissures and subsidences that affect the external slope of the atoll. The risk of collapse in the southern zone is not excluded: in fact, very wide (one to two metres) longitudinal faults penetrate the upper part of the outer flank over some tens of metres...". Cousteau also concluded that "it is clear that the permeability of the volcanic layer is locally increased by fractures caused by underground tests." "The premature and accelerated aging of the atoll certainly explains, to a large degree, the imminent transfer of the large yield nuclear tests to the atoll of Fangataufa." The scientific missions that have been permitted access to Moruroa, despite being allowed to take only a handful of

Figure 4 Mushroom cloud from atomic bomb test, Bikini Atoll, 1946.
(Photo: Corbis)

samples, have all detected the presence of artificial radioactivity either in or around the test site. This includes radioactive iodine, cesium 134, and plutonium in the lagoon and outside the 12 nautical mile exclusion zone (Greenpeace 1995). The Cousteau mission also found cesium 134, an artificial radionuclide not present in atmospheric fallout, and suggested it might "be necessary to attribute the origin of the Cs-134 to the underground tests". US scientist Norm Buske detected cesium 134 in plankton samples taken outside the 12 mile zone during a Greenpeace mission in 1990 (Greenpeace 1995).

Atmospheric nuclear tests were carried out on Christmas Island in 1957; subsequent reports have demonstrated that little contamination occurred.

The use of the Pacific Islands' waters as a shipping route or dumping ground for nuclear material was also seen as a big threat to Pacific Island states, in the event of a possible accident and spillage of radioactive materials. Pacific countries have strongly protested over the transhipment of waste plutonium through the region.

Spills

At the regional level, spills exert slight impacts, although in some places the influence of spills is moderate. There are many areas such as Suva harbour where small oil spills are a regular problem, but these have so far not led to visible oil deposits on reefs, or oil on beaches, with the impacts being much localised. The South Pacific Regional Environment Programme (SPREP) and the International Maritime Organization (IMO) formulated and approved a joint programme in 1998 to address shipping-related marine pollution; the Pacific Ocean Pollution Prevention Programme (PACPOL) (Nawadra 2004). PACPOL has been implemented since 1999 and has developed a regional policy for dealing with oil spills, but any large oil spill in the region would be a major disaster because of lack of clean-up facilities and the extreme isolation of the region for clean-up technology and assistance.

Socio-economic impacts

Economic impacts

Economic impacts of pollution result from increased medical costs, loss of tourism or recreational values, and costs of reduced fish marketability due to aesthetic perceptions.

Health impacts

The consequences of pollution on the health of the people from solid wastes, reduced nutrient intake and outbreaks of food poisoning from fish toxins, such as ciguatera, exerted a considerable impact on the population of the region. It is known, for example, that enhanced nutrient levels in lagoons result in more growth of macroalgae. The macroalgae are the substratum on which the dinoflagellates responsible for causing ciguatera live epiphytically: they are grazed by herbivorous fish, which are, in turn, eaten by carnivorous fish and, ultimately, people. By the time people consume the top predators, the ciguatoxins have reached dangerous concentrations (Temakei pers. comm.). Statistics describing the incidence of ciguatera poisoning in Fiji collected during the early 1990s showed the following increases in cases: 1989 (683); 1990 (787) and 1991 (1 012) (Singh 1992). Reporting of ciguatera cases is compounded by the fact that the symptoms are comparable to those of gastrointestinal problems (diarrhoea, pain, nausea). Ciguatera poisoning occurs in most Pacific Island countries, including Kiribati, Tuvalu, Solomon Islands, Samoa, Cook Islands, and French Polynesia. A 1992 summary of fish-poisoning incidence (however, not segregated into ciguatera and other) is provided below (Table 7). A study of 500 people in New Caledonia conducted in 1992 showed that 124 (almost 25%) had been intoxicated at least once (Amade 1993). These figures indicate that a significant proportion of ciguatera cases go unreported.

Atomic bomb testing began in 1948 in the Marshall Islands, with tests conducted on a number of atolls. The tests resulted in substantial movement and relocation of entire populations. In a detailed five-year study of 432 islands in the Marshall Islands which concluded in 1995, it was revealed that 15 atolls and single islands, almost half of the nation, were dusted by radioactive fallout from the tests carried out in the 1950s (Members of the GIWA Task team pers. comm.). See further comments under radionuclide pollution above.

Table 7 Fish poisoning statistics for Pacific Island countries, 1992 (not segregated into ciguatera and other forms of poisoning).

Country	Cumulative total for 1992	
	Cases	**Rate** (occurrences per 1 000 people in the population)
American Samoa	0	0.0
Cook Islands	148	8.7
Fiji	1 159	1.6
French Polynesia	773	4.4
Federated States of Micronesia	6	0.1
Guam	2	0.0
Kiribati	1 172	17.3
Marshall Islands	216	5.7
Nauru	0	0.0
New Caledonia	148	0.9
Niue	1	0.4
Northern Marianas	29	1.4
Palau	0	0.0
Pitcairn	0	0.0
Papua New Guinea	0	0.0
Samoa	122	0.8
Solomon Islands	0	0.0
Tokelau	13	8.1
Tonga	7	0.1
Tuvalu	168	19.8
Vanuatu	1 009	7.0
Wallis and Futuna	0	0.0

(Source: SPEHIS 1993)

Other social and community impacts

The endangerment of many species from pollution, and avoidance of areas due to increased degradation (resulting, for example, from inappropriate disposal of solid wastes) has a significant impact in the region. A short walk along any coastline close to human habitation in the Pacific Islands will reveal many examples of inappropriate waste disposal, even in areas where there is a municipal collection system such as in the city of Suva. Creeks running into Apia Harbour in Samoa are heavily choked with domestic rubbish, adjacent to people's homes and the roadway. The social and community impacts of this behaviour are not clear; annual clean-ups of some public areas are now common, but the fact that the same amount of litter has accumulated the next year indicates there has been little change of habits in the interim. The inappropriate solid waste disposal places a burden on the availability of land which is acute in small islands.

The displacement of entire populations in the Pacific region has had far-reaching social and community impacts. The most well-known cases involve the displacement of the population of Bikini Atoll in the Marshall Islands following nuclear testing – after many years the people are still unable to return to their island because of nuclear contamination. The people of Banaba Island (Kiribati) were relocated because their island was extensively mined for phosphates (from bird guano), rendering the island uninhabitable: many of these people now live on Rabi Island in Fiji, were they continue to be disadvantaged.

Conclusions and future outlook

Microbial, eutrophication, chemical and solid waste pollution is entirely related to human settlements and activities, and is likely to worsen as populations grow, become more urbanised and adopt westernised, disposal-oriented life-styles. Installation of proper sewage treatment plants in the main urban centres would do a lot to decrease levels of microbial pollution, and might also lead to ways of recycling scarce water resources. Solid waste disposal is a universal problem: it is a tragedy that some of the most beautiful places in the world are, on closer scrutiny, marred by garbage. It is often argued that the lack of financial resources is a hindrance to improving the situation, but much can be done by simple changes in awareness and shifts in attitudes, and by encouraging more environmentally friendly strategies for waste disposal. As long as the population tolerates or ignores accumulations of rubbish along the shoreline, and in creeks and rivers close to towns and cities, then the problem will persist. Civil society has an important role to play, and should exercise it and encourage the use, for example, of biodegradable wrapping materials.

Environmental impact assessment regulations or guidelines, if properly applied, would help to alleviate some of the worst examples of pollution in the region, and would engender a "polluter pays" ethic. Non-governmental organisations can (and do) play an important role in changing attitudes, but they need more help and support. Regional organisations and the international community are very active in their efforts to deal with the serious pollution issues relating to oil spills, ballast water disposal, and radionuclide pollution, these efforts are sometimes strong on policy, but weak on resources: it is likely that any major oil spill would create clean-up requirements of enormous proportions, and for which the region has practically no facilities to deal with. It will take many decades to deal with the potentially dangerous leakages that are lurking in World War II wrecks (and which have the potential to ruin important tourists destinations), and yet more decades to deal with the health and environmental results of nuclear testing. The large-scale application of poor land use practices is showing few signs of abatement: apart from the massive

increases in sediment loading on fragile and ecologically important coral reef ecosystems that this causes, there are other risks associated with loss of human life and infrastructure during cataclysmic events such as torrential rainfall during cyclones, or from land-slides caused by earthquakes. The amelioration of all impacts of pollution on the region will take a great deal of commitment in the coming years. Most importantly, every effort should be made to protect areas that are still pristine, since they will act as a reservoir of biological diversity for future generations.

Habitat and community modification

Loss of ecosystems and habitat modification are universal issues in the Pacific Islands region, with deforestation of catchment areas, mangrove "reclamation", urban development, sand mining, land-based mining and agriculture being the most devastating causal agents. The complete destruction of three islands by phosphate mining (Nauru, Banaba and Makatea) has led to financial ruin (Nauru) and displacement of entire populations (Banaba). More than 50% of some habitats (e.g. mangroves) has been lost or severely modified. Invasive species have caused considerable terrestrial ecosystem modification on some islands (e.g. Guam), but have been less of a problem in the marine environment, although knowledge is limited to studies of a few sites (e.g. Pago Pago Harbour, American Samoa).

The Pacific Islands region contains some of the most extensive and biologically important coral reef ecosystems in the world, and in general, the reefs are in good condition (Figure 5). Their status was most recently assessed in 2002, when it was observed that they had been severely impacted by major coral bleaching events in 2000 and 2002 (Wilkinson 2002). The economic and biological consequences of these events are still poorly understood. Near-shore seagrass communities are also vulnerable, particularly to eutrophication. Major socio-economic impacts include a reduced capacity to meet basic human needs, such as food and fuel. Other negative impacts occur in the tourism sector. Pacific Island communities have long utilised traditional medicines, a number of which are obtained from mangrove species: the loss of mangrove habitats reduces the availability of these medicines to indigenous peoples.

Among the most important habitats subject to modification are coral reefs, mangroves, and seagrass beds, as described in the Regional definition.

Environmental impacts

Loss of ecosystem

The Pacific Islands region has suffered moderate impacts because of the loss of habitats. For example, up to 40% of Fiji's mangrove forests have been destroyed, or reclaimed as it is termed, during the past 30 to 40 years. Two examples include destruction and land-filling during the early 1990s of a large area of mangroves adjacent to the Lami dump, outside of Suva, Fiji, to make way for a large container storage

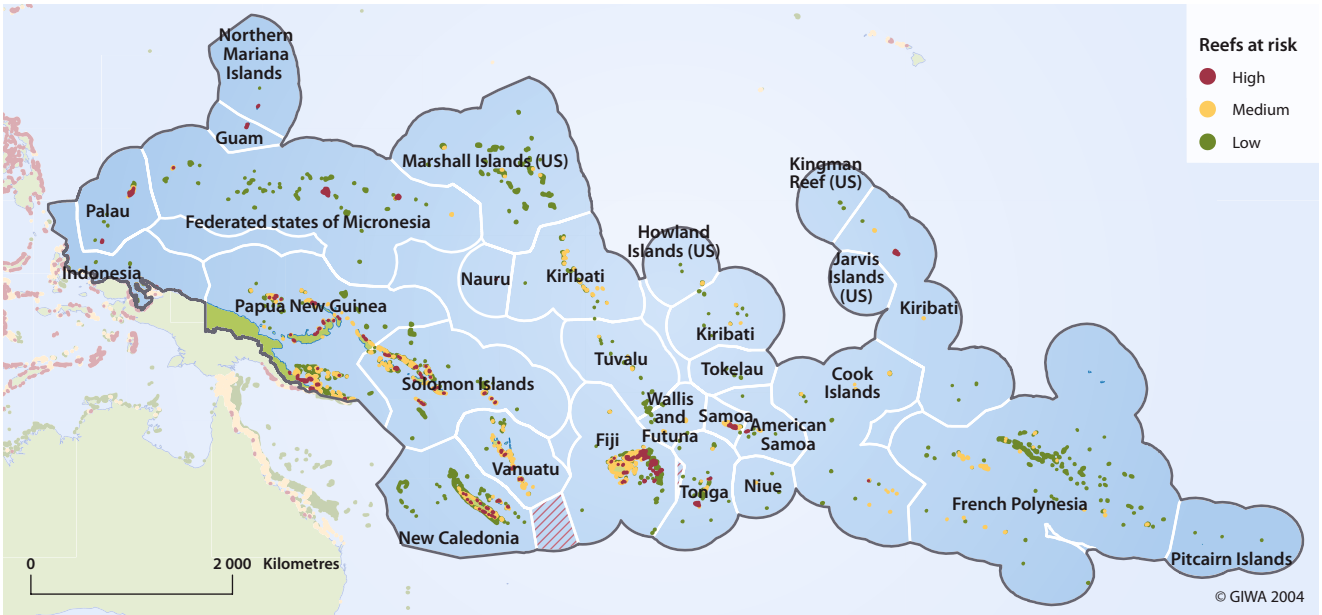

Figure 5 Reefs at risk in the Pacific Islands region.
(Source: Bryant et al. 1998)

Figure 6 Habitat and community modification – moonscape in Nauru resulting from phosphate mining.
(Photo: G.R. South)

area, and the "reclamation" of about 3 000 ha of coastal wetlands and mangroves close to Nadi, Fiji for the development of the Denarau Island tourism facilities. The status of mangroves in 11 Pacific Island countries is reported in SPREP (2001b). According to Jenkins (in SPREP 2001b), the Pacific Island region has 848 735 ha (or 2.4%) of the world's mangroves, with the largest areas occurring in PNG, Solomon Islands, Fiji and New Caledonia. It is estimated (Jenkins, in SPREP 2001b) that approximately 1.0% of mangroves in the Asia-Pacific region are lost annually.

The threats to mangroves in the region include:

- Conversion for agricultural or industrial use;
- Conversion for urban and tourism infrastructure;
- Disruption of hydrology due to roads and transport;
- Catchment degradation through impacts on freshwater flows;
- Overharvesting of fish and crustaceans;
- Potential conversion for aquaculture ponds;
- Potentially unsustainable forestry operations;
- Sea level rise and global warming.

Some islands have been almost completely destroyed by phosphate mining, such as Nauru and Banaba (Kiribati) and Makatea (French Polynesia) (Figure 6). The tricalcium phosphate deposits occur in crumbly surface or subsurface "nests" which are separated by walls and pinnacles of very hard dolomitic limestone; the mining results in a destruction of the plant cover and the environment. The deposits originally covered 80% of Nauru and Banaba, rendering the islands virtually uninhabitable in areas fully mined out (Dupon 1983). Other islands have been severely altered by nuclear testing, such as Bikini Atoll (Marshall Islands) and Moruroa Atoll (French Polynesia).

Sunken World War II shipwrecks remain a serious hazard to reefs and ecosystems of Pacific Islands, and as the wrecks age and rust out they are causing serious ecological threats through the leakage of oil and other hazardous materials (Monfils & Nawadra 2003, Nawadra 2004, Spennemann 1992). A summary of the number of known wrecks is provided in Table 8; the greatest numbers occur in Federated State of Micronesia, Papua New Guinea and Solomon Islands.

Table 8 World War II wrecks known from Pacific Islands, by Exclusive Economic Zone.

Country	Tankers and oilers	Total number of wrecks
Australia	3	49
Fiji	-	3
Federated States of Micronesia	16	150
Kiribati	-	6
Nauru	-	4
New Caledonia	-	10
New Zealand	-	2
Northern Marianas	1	64
Palau	9	77
Papua New Guinea	3	279
Republic of the Marshall Islands	1	49
Solomon Islands	2	158
Vanuatu	-	6
Total	35	857

(Source: Nawadra 2004)

The controversial construction of causeways in Tarawa (Kiribati) resulted in significant habitat modification and ecosystem loss including changes in water circulation in the Tarawa Lagoon, and changes to and losses in fish populations. Movements of fish into and out of the lagoon have been modified, and spawning areas for some species have been affected.

Modification of ecosystems

More than 50% of some habitats, particularly mangroves and coastal wetlands, in most countries in the Pacific Island region have been modified causing severe losses of biodiversity; especially on atolls and highly populated small islands. The extensive practice of seaweed mariculture in some countries has the potential to modify ecosystems if "escaped" plants become prevalent away from areas where they are cultivated. This has begun to happen in Fiji (South unpublished), where *Kappaphycus* plants are now found on reefs far from seaweed farms. There is little evidence yet, however, whether invasive species are a problem in any of the Pacific Islands, although they are known to occur in ports and harbours. In a recent report (Coles et al. 2003b) a total of 26 non-indigenous or cryptogenic species was detected in a survey of Pago Pago Harbour, American Samoa. This is relatively few introduced species compared with other Pacific sites examined (Guam, Hawaii and North Queensland, Australia) and the introductions are mostly restricted to the inner portions of the harbour and have not spread to adjacent coral reefs.

The harvesting of corals for the live-rock trade, and for use in the construction of septic distribution fields and building purposes is causing significant damage to back-reef areas, and undocumented modification of ecosystems (Lovell unpublished). The extensive harvesting of coral sand for the manufacture of cement and for building purposes in atoll countries causes significant habitat modification.

The status of coral reefs in the Pacific region has been summarised by Wilkinson (1998, 2000, 2002). Monitoring of reefs in the region has improved during the past few years, although information is lacking for large areas. Coral reefs are generally reported as being in good condition throughout the region, but severe bleaching events during the past decade have resulted in considerable coral mortality in those areas most affected. Up to 40% of coral colonies were bleached in March-April 2000 on Fiji's reefs, and considerable mortality resulted (Sulu et al. 2002). Considerable losses to reefs in New Caledonia in 1998 and 2001 were attributed to Crown-of-thorns starfish, coral bleaching or coral disease (Sulu et al. 2002). Pollution from sewage and sediments are mostly restricted to reefs adjacent to urban areas in the southeast and central Pacific (Salvat 2002). Wilkinson (2002) notes that the majority of the world's reefs, including those in the Pacific region, are outside of protected areas. Approximately 16% of the world's coral reefs were effectively destroyed during the major El Niño and La Niña events of 1997-1998, and although the Pacific Islands were largely spared then, they were severely affected in 2000 and 2002. The overall impact of this kind of habitat modification is still poorly recorded, but the effects on the fishery and biodiversity are likely to be considerable.

Green and Short's (2003) World Atlas of Seagrasses includes a report on the Pacific Islands region (Coles et al. 2003a). They report potentially significant impacts on seagrass communities adjacent to urban areas through the enhanced nutrient loads and sedimentation resulting from sewage disposal; they also refer to the difficulty of developing sustainable management strategies for seagrasses, because of customary ownership of land and near shore regions. Monitoring programmes established in the region under the SEAGRASSNET Global Monitoring Programme will improve our understanding of the status of seagrass communities in future years (Coles et al. 2003a).

Socio-economic impacts

Economic impacts

Major economic impacts include reduced capacity to meet basic human needs (e.g. food, fuel). The changes may have a negative impact on employment opportunities and associated changes in social structure. The loss of existing income and foreign exchange from fisheries, tourism, etc. is another major economic impact. It is extremely difficult to separate losses resulting from environmental impacts from those resulting from social upheaval, such as the military coups in Fiji and the breakdown of

law and order and the economy in Solomon Islands because of ethnic unrest. There has been little evidence, for example, that coral bleaching has had much impact on dive tourism income in Fiji, but a serious impact on tourism occurred during the May 2000 failed military coup. Events elsewhere in the world, however, have resulted in a rapid recovery of Fiji's tourism industry, as the country is now considered a safer place than other destinations. The potential costs of controlling invasive and alien species are another impact but no data are available; as mentioned above, they are not yet considered to be a serious concern.

Health impacts

The loss of traditional food and medicines, most of which were obtained from mangroves and native forests that have now been destroyed, traditional habitat protection as practised in pre-European contact times, as well as increases in non-communicable illnesses (e.g. diabetes, strokes and heart-diseases) caused by significant changes in lifestyle and diet resulting from overexploitation of resources are seen as serious impacts to the health and well-being of Pacific islanders. Climate change and habitat modifications are also affecting water exchange in coastal areas, giving rise to potentially increased populations of insect disease vectors such as mosquitoes.

Other social and community impacts

Social and community impacts identified in the region were: loss of food security because of the breakdown in traditional systems resulting from urban drift and the cash economy, and because of overexploitation of resources; loss of ecosystem functions because of habitat destruction and modification (as described above); cultural degradation through the erosion of traditional systems and the loss of traditional knowledge; increasing economic dependency because of increasing aid-dependency and on remissions from family members who have migrated overseas, and inter-generational inequity brought about by improved education opportunities and improved incomes of the new generation compared with the past.

Conclusions and future outlook

Habitat loss and community modification will continue to be issues for all Pacific Island nations for the indefinite future. There is an urgent need to increase the knowledge base about the region's ecosystems: understanding of the way that the ecosystems work is still rudimentary, and the biodiversity (species composition) of the majority of the many islands in the region has yet to be catalogued. Species extinctions have probably already occurred, and are continuing. Replanting of mangroves is occurring on a small-scale, and should be encouraged. The current trend towards locally managed marine protected areas is engaging increasing numbers of communities in the region and is likely to continue at an accelerated pace – this is an encouraging development. Monitoring of marine habitats and communities is important and likely to increase, with active regional and global programmes, as well as local communities, engaged. The move towards a Global Marine Assessment (GMA) programme, which is now in the planning stage, is a logical progression from the GIWA and should be implemented in the next few years. Maintaining the health of the region's ecosystems is one of the guiding principals of the Pacific Islands Regional Ocean Policy, and is critical, not only for health, food security and aesthetic reasons, but also for tourism, which is the world's fastest growing industry. Tourists are unlikely to want to visit places that are degraded or polluted; instead they will travel any distance to see pristine marine environments.

IMPACT Unsustainable exploitation of fish and other living resources

The exploitation of fish and other living resources drove much of the early development of the Pacific Islands during the more than two centuries since the first European contact, with whaling, bêche-de-mer (sea cucumbers) (Figure 7), and sandalwood being among the most important. Nowadays, other niche markets have taken on importance, including trades in aquarium fish (Tonga, Fiji, Solomon Islands), live coral (Fiji) and live fish (Papua New Guinea, Solomon Islands); the region's tuna fishery is the largest in the world, supplying some 50% of the world market.

The subsistence fisheries remain the mainstay of livelihoods and food security throughout the Pacific Islands. Per capita fish consumption in the Pacific Islands ranges from 55 kg/person/year in Fiji, to as high as 200 kg/person/year in Kiribati.

There is clear evidence of overexploitation of the inshore and reef fishery in most Pacific Islands: this is being driven by population increases and consequently greater demands for fish, by a lack of regulation of the subsistence fishery, by the use of illegal fishing methods, by improvements in technology (and thus ability to catch fish) and by a lack of sufficient protected areas for the inshore fishery. Western-style fisheries management methods have not led to sustainable inshore fisheries in the Pacific Islands context, and there is now a realisation on the part of many fishing communities of the need to combine traditional conservation and modern strategies in the management of their fishing areas. The establishment of fish reserves or locally managed marine protected areas is now becoming a trend in a number of countries, including Fiji, Samoa, Cook Islands and Papua New Guinea.

Figure 7 Bêche-de-mer on sale at Suva market, Fiji.
(Photo: G.R. South)

Environmental impacts

Overexploitation

Total coastal fisheries production in the Pacific Islands amounts to more than 100 000 tonnes per year, worth a nominal value of 262 million USD per year (Dalzell et al. 1996). About 80% is from subsistence fishing, and about half of the production comes from fishing on coral reefs (Figure 8). The Asian Development Bank (ADB 2001) notes that the official data on the percentage contribution of fisheries to the GDP in 1999 ranged from 0.6% (PNG) to 12.0% (Kiribati). New estimates from their study, however, showed that the estimates of contributions to GDP are almost double in Kiribati, Palau and the Federated States of Micronesia, but are lower in Marshall Islands, Samoa and Cook Islands, compared with the 1999 estimates. The average contribution across all Pacific Island countries is now estimated as 7.0% of GDP. The reasons for the differences are largely because subsistence fishing was not included in previous estimates. The ADB also noted that fishery trade data for the Pacific Islands region underestimate the value of fisheries exports.

Invertebrates are the most valuable inshore resources, and include bêche-de-mer (sea cucumbers) (Figure 7), trochus and pearl oysters. Mariculture of shrimps, as well as seaweeds (Figure 9) and some finfish, is increasing in popularity. Dalzell et al. (1996) point out that the greatest future influence on coastal fisheries in the Pacific is likely to come from Southeast and East Asia, where the demand for high value coastal fishes and invertebrates has led to large-scale depletion and has motivated entrepreneurs to seek stocks in the neighbouring Pacific Islands. Examples of this include the live fish trade in Solomon Islands and Papua New Guinea.

Preston (1993) provided a detailed account of bêche-de-mer biology and the fishery in the Pacific Islands. This fishery has been important since the early days of European contact. European or American trading vessels conducted collecting expeditions in New Caledonia and PNG, and the first trade in Fiji began in 1813. The fishery had an enormous influence on the lives of Pacific Islanders, especially during the first half of the 19th century, and ultimately led to major demographic and political changes in some parts of the region (Ward 1972). The fishery has continued to be an important although variable source of revenue for Pacific Islands, and has followed a "boom and bust" pattern for a wide range of reasons (Ward 1972). The bêche-de-mer trade has had significant (and probably irreversible) environmental consequences, the most obvious being deforestation of coastal areas for firewood, with 10 tonnes required to smoke each tonne of bêche-de-mer (Preston 1993).

It was agreed that there is clear evidence of fish overexploitation in almost all of the countries and territories in the region, involving a wide range of species (such as giant clams) being exploited beyond their Maximum Sustainable Yield (MSY), or even to local extinction. MSY is difficult to apply to the multi-species fisheries of the Pacific Islands (apart from pelagic, highly migratory species such as tuna). In part because of a lack of biological and stock data for most species, but also due to a lack of capacity within the small fisheries jurisdictions of the Pacific Islands who could carry out such work and there are few examples where MSY has been calculated. As pointed out by Dalzell et al. (1996), most of the research on Pacific Island species has been carried out by scientists from outside of the region, and much of the data have been obtained from neighbouring countries such as Australia and those of Southeast Asia.

An example of overfishing is from Samoa (Skelton et al. 2002) where inshore fish landings declined dramatically from 250 million tonnes in

1986, to just over 50 million tonnes in 1994. Bottom fish were overfished by an estimated 30% of the MSY in 1992, which ultimately led to the collapse of that fishery. Species that are fished unsustainably include mullets (Mugilidae), sharks (for the Asian shark fin trade and through by-catch), hump-head Maori wrasse (*Cheilinus undulatus*), large groupers (Serranidae) for the live fish trade, and other bottom fishes, eels, giant clams (*Tridacna* spp., *Hippopus hippopus*), bêche-de-mer (Holothuroidea), Coconut crabs (*Birgus latro*) and other targeted crab species, and sea turtles. The overfishing is particularly acute for valuable species and species found around the main urban centres where there is very high demand for fish from urban communities, but is less of a problem for non-targeted species and those found outside urban areas.

Excessive by-catch and discards

In the Pacific Islands by-catch is defined as "any catch of species (fish, sharks, marine mammals, turtles, seabirds, etc.) other than the target species. 'Incidental catch' can be regarded as synonymous" (Bailey et al. 1996). By-catch and discards occur in the offshore tuna fishery, principally from purse seine and long-line fishing, but it is difficult to obtain accurate estimates on the levels and species caught. The SPCs Oceanic Fisheries Programme has devoted considerable attention to the by-catch issue. Williams (1996) provided a detailed case study for the region, and SPREP (2001c) has reviewed the turtle by-catch for the western and central Pacific Ocean tuna fishery, and have estimated that more than 2 100 turtles are accidentally caught each year, of which about 25% might be expected to survive (principally those caught by purse seines). A considerable number of species of sharks and other fishes feature in the by-catch.

Data on by-catch obtained from ship's log sheets has been shown to be much lower than estimates obtained by observers (Williams 1996). This suggests a reluctance to report the full extent of by-catch, or even the suppression of information. For large sections of the tuna fishery, observer data are absent, and it is likely that this situation will prevail because of the high cost of observer programmes and the fact that observers are not always allowed on tuna fishing vessels from some countries. Rather less is known about by-catch of seabirds in the region, although indications of the likely extent of the problem may be gleaned from Rivera (2002). WWF (2003) has stated that over 300 000 whales, dolphins and porpoises are killed each year as a result of by-catch in

Figure 8 Reef fish on sale at the Suva market, Fiji.
(Source: G.R. South)

fisheries and entanglement in drifting fishing gear; how many of these are in the South Pacific region is not stated.

Destructive fishing practices

Although destructive fishing practices exert a moderate impact at the regional scale, in some countries, the impacts are more severe. The use of a variety of destructive fishing techniques, particularly explosives including dynamite, fish poisons, pesticides and chemical poisons, as well as the use of overefficient fishing gear (e.g. small-meshed gill nets, night spear fishing with spear guns and torches, purse seining, SCUBA, etc.) has led to widespread reef and habitat destruction and the collapse of stocks of a number of species, and this has led to a banning of such fishing, for example, in American Samoa. Blast fishing is highly destructive. A blast at close range shatters the skeletons of all corals destroying the complex substrate that attracts many of the fish in the first place and at increasing distances from the blast all fish and invertebrates are killed irrespective of whether they are desirable (Jennings & Polunin 1996, Cesar et al. 1997, McManus 1997).

Figure 9 Sale of *Hypnea* seaweed at Suva market, Fiji.
(Photo: G.R. South)

Poison fishing is more insidious than other fishing techniques because the more remote reefs that generally escape land based threats such as pollution, sedimentation and coastal development are the reefs that prime targets for this method of fishing (Bryant et al. 1998). Cyanide fishing also causes damages the corals themselves. At high concentrations cyanide kills corals outright (Jones & Steven 1997) and at lower concentrations it impedes the photosynthetic function of the symbiotic zooxanthellae and causes bleaching in corals (Jones & Hoegh-Guldberg, 1999) which, in turn, slows the growth of the coral and renders it more vulnerable to other disturbances (Wilkinson et al. 1999). In addition, the harvesting of corals for the live rock trade is exacerbating the problem since it results in modification of back-reef areas where the harvesting is carried out. For additional details, see the Causal chain analysis of destructive fishing below.

Decreased viability of stock through pollution and disease

Pollution exerts slight to moderate impacts on the viability of stocks. For example, concentrations of tributyl tin (TBT), which is a major component of antifouling films that are applied to the hulls of boats to prevent the settlement and growth of marine organisms, exceeding 2 µg/l have been detected near slipways and have accumulated to hazardous levels (Bryan et al. 1986). The accumulation of TBT in marine organisms produces a variety of problems, particularly sex modification (imposex) in oysters and other bivalves in Suva Harbour (Tamata et al. 1993) and changes in the immunological responses of fish and other aquatic organisms (Weeks et al. 1990, Burton et al. 2002). In addition, in harbours and other areas where there is heavy maritime traffic concentrations of creosote, which is a polyaromatic hydrocarbon based treatment commonly used on pylons, wharves and netting to protect against fouling with marine organisms, 10 times greater than that required to cause the development of eye cataracts and gill necrosis in fish, and carcinogenesis and changes in immune responses in humans and other animals (Rose et al. 2000) have been recorded. Other pollutants, such as polychlorinated biphenyls (PCBs) from military installations in Guam and DDT are present and can be concentrated through the food chain and accumulate in the tissues of large predatory and commercially valuable fish such as swordfish (*Xiphias gladius*).

There is also serious concern over the potential impacts of sewerage and domestic waste and sediment on fisheries stocks. In Samoa, Skelton et al. (2002) note that inshore pollution and increasing sediment loading have resulted in a steady replacement of corals with seagrasses and algae, and this has resulted in a collapse of some reef fisheries. A problem throughout the region is the lack of capacity to measure the impacts of pollution on flora and fauna. An example quoted in Skelton et al. (2002) is of a solvent spill from a fuel tanker docked at Apia Wharf in

Samoa in 1999, where clean-up measures were minimal and the impact on the marine environment could not be measured because of lack of equipment and expertise.

Impact on biological and genetic diversity

The biological and genetic diversity of the region has suffered moderate impacts. For example, the introduction of the Nile tilapia (*Oreochromis mossambicus*) in Kiribati has resulted in the displacement of some of the local fauna and the occupation of new habitats. Nile tilapia has been introduced to most of the islands in the region. In Fiji, this species has escaped into many natural waterways, where it has replaced native species.

Socio-economic impacts

Economic impacts

The deterioration of health leading to increased cost of health care was considered an important impact. Many of the impacts are localised, and the most serious are concentrated in the urban centres (Crosby et al. 2002). With a few exceptions, however, it is unlikely that these impacts have had a measurable impact on income from tourism or sale of fisheries products. Overexploitation is the most serious problem, with examples like the live-fish trade most threatening. Measurement of increases in health-care costs relevant to environmental impacts is problematical, since these have to be considered in the light of changes in health care systems themselves.

Health impacts

Loss of traditional food sources resulting in the use of alternative foods, usually cheap and of low nutritional value (e.g. mutton flaps, turkey tails, tinned-fish, corned beef, etc.), results in deterioration of health and increases in non-communicable diseases. This situation is prevalent throughout the entire region, and includes rural as well as urban populations.

Other social and community impacts

Changes in lifestyle, which may include the disintegration of traditional systems, increasing dependence on the cash economy and increased dependence on aid, are important social and community impacts throughout most of the Pacific Island states. These are issues that are addressed in various parts of this analysis (Members of the GIWA Task team pers. comm.).

Conclusions and future outlook

Management of inshore and subsistence fisheries is undergoing a paradigm shift towards co-management in recognition of the need for sustainable use of resources. It remains to be seen whether this will be sufficient to arrest the continued overexploitation of fish resources. The establishment of locally managed marine protected areas is proceeding apace in the region, and is being strongly supported by governments, NGOs, donors and communities. There are serious problems, however, in that the subsistence fishery remains unregulated and generally unmanaged, destructive fishing continues unabated in some countries, and the increasing demand for fish and fish products continues. Most importantly, there is a very weak database of information on the biology, reproduction and ecology of even the most important target species of the subsistence and artisanal fisheries, which means that there are inadequate data on which to base sound management decisions.

Aquaculture is one possible way of supplementing dwindling fishery resources, but it has largely been unsuccessful in the Pacific Islands, is unregulated and has the potential to cause environmental problems. Governments have difficulties in enforcing fishery regulations because of shortage of staff and other resources: strategies to combine traditional law with national laws may be one way of dealing with this problem; the Village by-laws employed in Samoa are a good example of this. Pollution, habitat destruction and environmental degradation are contributing to a reduction of fishery resources and biodiversity, and will have long-term effects on the fishery if they are not dealt with. Overexploitation of fish is likely to continue for the indefinite future in the Pacific Islands region, and will continue to impact the livelihoods and food security of the people. Health issues associated with an increased dependence on imported foods are likely to grow over the coming years, as they are replacing the healthier diets of local fish and vegetables. The lucrative tuna fishery may continue to offset some of these impacts, but it too will need to be properly managed, and the Pacific Island countries should continue to press for a greater return on the tuna resource, since most of it is accrued by other nations.

Global change

Global change is the most important crosscutting concern for the Pacific Islands region, impacting almost all of the issues reviewed in the Assessment. The most significant overall impacts of global change include:

- Freshwater availability;
- Food security and availability;
- Changes in productivity of agriculture, fisheries and forestry;
- Human migration;
- Increased costs of human health care.

An examination of paleoclimatic and geological events shows that factors associated with global change, such as changes in sea level and sea surface temperature have been integral to the evolutionary history of the Pacific Islands. Their largely volcanic origin also means that the geological history of the Pacific Islands is at best indirectly linked to that of adjacent continental plates and the tectonic events associated with them. The difficulty of dealing with global change is that data are imprecise and are the subject of a variety of predictions and scenarios that are not always agreed upon by the scientific community and that are not easily understood by the non-scientist. Furthermore, global change is largely the result of human-related activities far away from the Pacific Islands region: the people feel vulnerable, and cannot do much to change the course of events. Predictions of the disappearance of some of the islands in the atoll countries, for example, are already proving to be correct.

The difference between the past and the present, however, is in the rate and scope of global change: there seems little disagreement that sea levels are rising and that sea surface temperature is increasing at much faster rates than in the past. These changes are going to have a major impact on the health of coral reefs, which are the life-blood of the Pacific Islands. They are also going to significantly affect the socio-economics of the Pacific Islands countries, which depend on their marine environment for their income and well-being. Corals in the Pacific Islands are growing close to their maximum survival temperature, and sustained elevated temperatures of even 1-1.5°C above average can result in coral bleaching and/or coral mortality. Increases in the incidence of coral bleaching in the region are strong evidence of the kinds of changes that are occurring, but their impact on biodiversity and the fisheries is still poorly understood. At the same time, increases in UV-B radiation caused by the ozone "hole" over the South Pole, and changes in the ocean's CO_2 source and sink functions will have significant negative effects on human health, and on the future health of coral reefs, respectively.

Environmental impacts

Changes in hydrological cycle

A moderate impact is noted for the region. This is evident in the increasing frequency of extreme events such as floods and drought. Better documentation of this phenomenon is however required (Members of the GIWA Task team pers. comm.). The Intergovernmental Panel on Climate Change (IPCC) reports prepared by Pacific Island countries are one useful reference source on this topic.

Sea level change

Due to the vulnerability of many islands and atolls to encroachment by the sea, the issue was considered to have a severe impact. The seriousness of sea level changes was recently raised by the Tuvaluan Prime Minister, who stated that three islets in his country have been submerged due to sea level rise. The team noted that although the IPCC (Mitchell et al. 2003) reported a 1-2 mm sea level rise on a global average per year, the figure for some of the Pacific Islands is much higher, approximately by 10 times (e.g. Tonga 20 mm per year, Solomon Islands 22 mm per year), whereas in others it may be close to the IPCC predictions, or lower (e.g. Samoa). The South Pacific Sea Level and Climate Monitoring Project (Flinders University, Australia) monitors sea level rise in selected Pacific Island locations through the deployment of a series of tide gauges. Data from long-term (more than 50 years records) sites show a mean annual increase in sea level of 1.07 mm. When more stations are included in the records (those with more than 25 years records), the mean is lowered to 0.8 mm/year (i.e. lower than the IPCC estimates). It is thus not clear whether there is an acceleration in rate of sea level rise (Mitchell et al. 2003). As there are many factors that influence the measurement (and prediction) of sea level changes over time, it is likely that the jury will remain out for some time on this complex issue.

Increased UV-B radiation

The United States Department of Energy's Atmospheric Radiation Measurement (ARM) Programme collects data from its Tropical Western Pacific (TWP) locale, which lies roughly between 10° S to 10° N, and 135° E to 150° W (Clements et al. 2000). The data shows that UV radiation in the Pacific Islands regoion is not excessively high (compared with Australia for example).

Ozone plays an important role in absorbing harmful ultra-violet radiation (UV-B). Increased exposure to UV-B results in increased levels of skin cancers in humans. Increased levels of UV-B are also known to be harmful to living, aquatic organisms. The Montreal Protocol, which came into force in 1989, is a landmark agreement designed to protect the atmospheric ozone layer, and Pacific Island countries are parties to the agreement. The Montreal Protocol's Multilateral Fund supports the Pacific's Regional Strategy to comply with the protocol (covering eight core countries: Fiji, Federated State of Micronesia, Marshall Islands, Palau, Solomon Islands, Tonga, Tuvalu and Vanuatu). These governments have committed themselves to a total CFC phase-out by 2005 (SPREP 2003).

Participating countries are party to the Pacific Islands National Compliance Action Plan which requires:

- Establishment of national ozone unit office and committee;
- Public awareness and education;
- Establishment of licensing and monitoring systems;
- Training of trainers, and subsequent training of refrigeration technicians, on good practice refrigeration;

Figure 10 Mushroom corals, Ofu, American Samoa.
(Photo: A. Cronish, Reefbase)

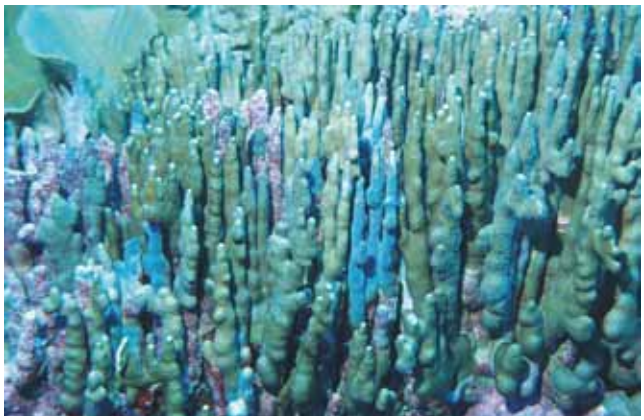

Figure 11 Blue corals, Swains Islands, American Samoa.
(Photo: A. Cronish, Reefbase)

- Training of customs officials on monitoring and control of Ozone Depleting Substances (ODS) imports;
- Consideration of tax incentives to promote use of substitutes and alternative technology;
- Ban on new installations and equipment using controlled ODS;
- Ban on imports of CFCs and other ODS (except hydrochlorofluoro carbons) with exemptions for essential uses.

Changes in ocean CO_2 sources/sink function

At present, there is a large deficiency of knowledge as well as data for the region, although the high percentage of coral reefs found within the Pacific Islands (no accurate measures of the area of coral reefs exist for most countries in the Pacific), should be considered if there are changes to ocean CO_2 concentrations. Hughes et al. (2003) state that projected increases in CO_2 and temperature over the next 50 years exceed the conditions under which coral reefs have flourished over the past half-million years. As noted elsewhere in this report, healthy coral reefs are fundamental to the food security and protection of the Pacific Islands. However, if concentrations of atmospheric CO_2 continue to increase, they will cause a concomitant increase in the acidity of the sea water which will, in turn, cause a decline in the available carbonate for the skeletons of corals and other calcareous marine organisms (Wilkinson & Buddemeier 1994, Hoegh-Guldberg 1999, Souter & Linden 2000). Although the available published evidence and predictions do not relate directly to the Pacific Islands, Hoegh-Guldberg (1999) predicts that, at the present rates of increase of atmospheric CO_2 concentrations, the rate of calcification of corals will decrease by between 14% and 30% by the year 2050 and a net loss of calcium from the system through physical and bioerosion will weaken the framework of reefs. Once the structural integrity of the reefs is compromised, the reef itself can be rapidly eroded resulting in the destruction of coastlines, loss of housing, tourism and coastal ecosystems such as mangroves and seagrass beds (Wilkinson & Buddemeier 1994) and, in a worst case scenario for a low-lying country like Tuvalu, loss of entire nations. Thus, a threat such as increases in atmospheric CO_2 could have a significant impact on the region. In a less dire prediction, Hughes et al. (2003) comment that reefs will change rather than disappear entirely, as changes in species tolerance and species composition occur (Figures 10 and 11).

Increase in sea surface temperature

The increase in coral bleaching events in the Pacific Islands region e.g. Palau bleaching in 1998, southwest Pacific bleaching affecting Solomon Islands, Fiji and Tonga in 2000 and 2001, as a result of increased sea surface temperature exerted severe impacts on the region. Cumming et al. (2002) reported in detail on the mass coral bleaching in the Fiji Islands in 2000. 64% of all scleractinian corals surveyed were bleached (partially or fully), in all regions except the far north of Vanua Levu Island. At southern sites, more than 80% of colonies were bleached. It was estimated that 10-40% of coral colonies had died from bleaching within 4 months of the onset of the bleaching. Post-bleaching surveys of the Suva Barrier Reef and Beqa Lagoon in Fiji did not, however, detect any immediate changes in fish stocks, although longer-term changes are still being monitored (Carlson unpublished). The impact of the 2001 bleaching was less marked in Fiji. Recovery is occurring in most sites, although changes in coral species biodiversity have occurred. At Palolo Deep Marine Reserve in Samoa, bleaching of shallow-water corals is a result of extreme low tides; recovery of these communities (dominated by *Acropora* spp.) is rapid (Skelton unpublished). A number of Array of Real-Time Global Observation (ARGO) floats were being deployed in the Pacific Islands region, including those under the Scientific Educational Resources and Experience Associated with the Deployment of Argo (SEREAD) project, to monitor environmental parameters such as temperature, salinity and current movement. The University of the South Pacific has recently established a Pacific Centre for Environment

and Sustainable Development to serve as a focal point for integrated study of environment and sustainable development issues. The Global Coral Reef Monitoring Network (GCRMN) operates in the Pacific Islands region through various nodes (Wilkinson 1998, 2000, 2002).

Socio-economic impacts

Economic impacts

Global change will have far-reaching economic impacts on the region, as already outlined under this concern. An analysis of the economic impacts would be a major undertaking in itself, far beyond the scope of this report, since all aspects of life will be affected, most importantly those associated with freshwater availability; food security; changes in productivity of agriculture, fisheries and forestry; human migration; and increased costs of human health care (Members of the GIWA Task team pers. comm.).

Economic issues often override environmental concerns in government planning and policies. There is a trend towards recognition of the need for more integrated planning, to comply with global conventions and agreements through the development of appropriate national laws and regulations, and a number of Pacific Island countries have drafted or have even enacted new environmental laws and policies which recognise these needs. These are, however, the exceptions: the sustainability ethic is widely spoken about, but in reality is an almost unachievable goal given the financial and socio-economic constraints under which governments have to work. Small populations, inadequate funding, lack of the necessary human resources and lack of political will are all contributing to the current situation that is leading to more and more destruction and modification of habitats and ecosystems in the Pacific Islands. There is also a long-standing dependency on donors (who are often the same countries that were once colonial governors), and donor policies have in themselves been strong external driving forces. There has also been, regrettably, a culture of corruption in some countries where government or private sector leaders have compromised standards or ethics in return for under the table deals with outsiders willing to fund major developments.

Health impacts

The health impacts are related to changes in diet because of depletion of local fish stocks and the use of imported and inferior foods such as tinned fish, resulting in increases in non-communicable diseases; reduced availability of potable water supplies which is becoming prevalent throughout the region and increasing the risk of water-borne diseases such as hepatitis, increased incidence of vector-borne diseases such as malaria and dengue fever (Members of the GIWA Task team pers. comm.). Dengue fever outbreaks have been serious in Fiji, for example, where all sectors of the community are vulnerable and deaths have occurred, especially among children.

Other social and community impacts

The most important impacts were identified as employment security; changes in resources distribution and political jurisdiction over them; human migration due to inundation of coastal areas; salination of groundwater; and damage to human life and property from storm surges, increased cyclonic events (Members of the GIWA Task team pers. comm.). For example, on the Carteret Islands (Papua New Guinea), low-lying islands some 200 km from Bougainville, serious increases in sea level rise and increases in storm surges in the past few years have rendered some of the islands uninhabitable. The people who inhabit these islands were relocated there during the Bougainville civil war. These people have extensively dynamited the reefs around the Carteret Islands. There is some disagreement among experts as to whether the changes are the result of reef destruction, or sea level rise, or a combination of both. The situation there does, however, characterise events likely to occur more frequently in the Pacific Islands in the future.

Conclusions and future outlook

Global change will continue to have a major influence on all aspects of the lives and economies of Pacific Island peoples for the indefinite future. Much will depend on the rate and extent of changes, which are unevenly distributed in the region, and on how numerous strategies on the part of the international community will ameliorate the impacts. It is clear that even in the most modest scenarios, changes will continue well into the present century; if the more extreme predictions occur, then most of the atoll nations will disappear beneath the ocean, and coastlines and communities around most of the high islands will be inundated within the next 50 years. Serious socio-economic consequences are inevitable in such situations. In the end, it will be merely academic to argue about the actual levels of change; some islands are already disappearing in Tuvalu, and discussions are on-going with the New Zealand Government who has offered to accept the Tuvaluan people when they become environmental refugees. The impacts will occur at every level of society and in every sector, and will require substantial changes in all public and private institutions. Regular monitoring of marine and coastal ecosystems, improved prediction of cyclones, tsunamis and ENSO events will be required to assist Pacific Island countries prepare for the impacts of global change. Many of these systems are in place, but what is needed are improved ways of distilling the results into language that is understandable by civil society. Amelioration of the effects of global change at the country or local level will require a much greater understanding of the issue, and how it impacts on almost every aspect of daily life.

Priority concerns for further analysis

On the basis of information incorporated into the assessment and the most likely future scenario, it was concluded that all issues, apart from those relating to improved control of fisheries, were going to deteriorate during the next 20 years, and that the most important cross-cutting concern was Global change, since the magnitude of the impacts of many of the issues assessed is influenced directly or indirectly by climate change.

Considering the likely impacts of each of the major concerns on the Pacific Islands region during the next two decades, the following order of priority was established among the major concerns for the allocation of effort for environmental and socio-economic remediation:

1. Global change
2. Overexploitation of fish and other living resources
3. Habitat and community modification
4. Pollution
5. Freshwater shortage

Although the Pacific Island states have become important advocates regarding the impacts of climate change because of their vulnerability, initiating remedial efforts to adequately address Global change in the immediate future will be difficult. In a precious few cases the influence of Global change is obvious, for example, the prevalence of extreme droughts caused by the increasing magnitude and frequency of El Niño events or the decline in live coral cover caused by bleaching that is induced by elevated sea surface temperatures. For the most part, however, environmental and socio-economic impacts that are directly attributable to Global change are, at present, obscured by the consequences of other, more demonstrably deleterious anthropogenic activities such as the use of destructive fishing techniques or the discharge of toxic effluents. In addition, there is a lack of precise data, a variety of different scenarios looking into the future and a lack of agreement of details by different scientists. Moreover, the impacts of Global change are highly complex, and are likely to vary among the different island types of the Pacific and be exacerbated by a number of social and economic issues, particularly high population growth rates in some countries, migration from rural or high land to urban (coastal) areas, continued breakdown of traditional lifestyles, shortage of land and loss of soil quality, deterioration of health, increased dependency on aid, and evolution to the cash economy.

While the current and potential future impacts of Global change and its influence of each of the other major concerns have been described in the assessment section above, Global change differs from each of the other major concerns because its root causes tend to originate beyond the borders of the region, making them extremely difficult to manage or mitigate. The root causes of Overexploitation of fish and other living resources, Habitat and community modification, Pollution and Freshwater shortage, on the other hand, tend to be local and are therefore, more amenable to policy interventions. As a consequence, the Causal chain analysis focused on a number of case studies that covered several of the major concerns and were representative of some of the more severe problems that are affecting the Pacific Islands region identified in the assessment namely, Freshwater shortages caused unsustainable use of groundwater resources, modification of stream flows caused by alterations of land-use patterns and variation in climatic patterns, overexploitation of living resources through overfishing and the use of destructive fishing techniques and the decreased viability of fish stocks caused by pollution and disease.

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details on the methodology, please refer to the GIWA methodology chapter.

Freshwater shortage

There is a general lack of data on freshwater supply issues in the Pacific Islands region. The issue of water management has been thoroughly discussed in the region in various forums. In one of the recent forums held in June-July 2002 in Sigatoka, Fiji, various country representatives voiced the issues that they faced in their homelands.

There is a common element on the various issues, which is applicable throughout the region. Some of the issues include:

- Need for freshwater management through improved monitoring regimes;
- Infrastructure to address water quality and contamination, especially in periods of droughts or heavy rains;
- More transparent government policies that are applicable to the local scenario;
- Lack of funds to upgrade facilities;
- Lack of capacity in water management, which is exacerbated by the lack of opportunities for local staff to undergo appropriate training;
- Inadequate effort to promote and raise awareness of sustainable use of water;
- Legislation needs to be applicable and enforced to address water abuse and wastage;
- In small atolls, bore holes are situated too close to the sea and become contaminated by saltwater;
- Increasing populations continue to place pressure on water supply;
- Land use and ownership conflicts between communities and governments;
- Lack of community participation in the development of government policies, especially on issues that affect the communities (such as water metres);
- The lack of a code of practice on the use of chemicals in industries (e.g. pesticides in agriculture), having the potential to pollute the water supply.

Burns (2002) has written a detailed review on water resources and the impacts of climate change on Pacific Island countries, stating that freshwater is "an imperilled, extremely limited resource in most PIDCs". According to a World Bank study, only 50-70% of the residents of Samoa and 44% of the residents of Kiribati have access to safe water (Hoegh-Guldberg et al. 2000), and this is reduced to 10% in Papua New Guinea (Lauerman 1997) (see also Table 5). Current and future water shortages are attributed to rapid population growth, lack of infrastructure and natural and anthropogenic factors. Other threats identified by Burns (2002) include sea level rise, pollution, and ENSO-related droughts.

Two of the three issues included within Freshwater shortage are addressed below. Although modification of stream flow exerts only a slight impact at the regional scale, this issue is of significant importance to some of the high islands in the region (e.g. Fiji).

Modification of stream flow – Rewa and Ba river basins

The Rewa River drainage basin is located in eastern Viti Levu, Fiji (Figures 12 and 13), and is the largest fluvial system both in Fiji and the tropical South Pacific Islands in general. The Rewa Basin spans 2 900 km^2, or approximately 1/3 of the island of Viti Levu. It has a recorded history of major floods, and its major tributary the Wainimala River gives rise to high sediment yields. Much of the suspended load is from bank erosion. The 3.2 cm/year accretion rate in Fiji exceeds rates reported from other fluvial systems in the region. The catchment is subject to very high use from agriculture and forestry; it is likely that very little if any of the catchment has been unaffected by humans, and most of the forest areas are of secondary growth. The major references for the catchment are those of Terry et al. (2001, 2002).

Figure 12 Location of the Rewa and Ba rivers, Viti Levu, Fiji.

The Ba River drainage basin (Figures 12 and 14) is located on the northwestern side of Viti Levu, and is the third largest fluvial system in Fiji, draining an area of 937 km^2. A difference between the Ba and Rewa drainage basins is that the latter is a centre of sugar cane growing. The average flow rates are 10 m^3/s in dry seasons and 60 m^3/s in wet seasons. During the 1994 sugar cane crushing season, dissolved oxygen fell to near zero along at least 7.5 km of river length, due to the presence of mill wastes, which have a high BOD. Faecal coliform bacterial levels are elevated both during crushing and post-crushing seasons, and the sugar mill causes most of the oxygen depletion. The major reference for the Ba catchment is by Anderson (1997).

The causal chain diagram for the issue modification of stream flow in Rewa and Ba river basins is presented in Figure 15.

Environmental impacts

The environmental impacts are the change in river characteristics, which include:

- Changes in flow;
- Changes in sediment load;
- Changes in chemistry;
- Changes in microbiology.

Immediate causes

Increased sediment loads

Until the middle of 1991, no measurements had been made on the amounts and composition of the suspended solids in the Rewa River (Togamana 1995). Hasan (1986) used a range of formulas to calculate the relationship between the discharge and the sediment load for the Rewa River, and he estimated that the average sediment load was approximately 10 million tonnes per year. Morrison (1981), Hasan (1986) and Nunn (1990) estimated that soil loss in the Rewa catchment was 34 to 36 tonnes/ha/year and stated that the losses in the four main tributaries of the Rewa stood at: Wainimala 30 tonnes/ha/year, Waidina 69 tonnes/ha/year, Wainibuka 24 tonnes/ha/year and Waimanu 79 tonnes/ha/year. The Fiji Government, since 1983, has spent about 6 million USD annually on dredging in order to alleviate the problem of flooding in the Rewa and other rivers (Togamana 1995).

Decreased water flow

The decrease in the low water flow is attributed to two main factors: (i) decrease in rainfall, and (ii) increase in water-uptake through commercial afforestation. In the Ba River, average flows are affected during the dry months due to changes in the rainfall patterns and average river flows are 10 m^3/s in dry seasons and 60 m^3/s when wet (Anderson 1997). Rainfall seasonality is more pronounced in the northwest region,

Figure 13 Satellite image of the Rewa River and delta.
(Photo: SOPAC)

Figure 14 Satellite image of the Ba River and delta.
(Photo: SOPAC)

which receives only 20% of the annual rainfall total of approximately 1 900 mm in the dry months (Terry & Raj 1998). This results in rivers in the northwest experiencing very low stream base flows causing a severe depletion of available water resources (Terry & Raj 1998). Capital developments have encouraged the planting of fast growing and economically important timber trees since the 1950s. In Fiji, 60 000 ha of pine were planted in areas that were once covered by grassland. This may have led to excessive uptake of water and a reduction in the dry season water flow by 50-60%, putting the operation of a hydroelectric plant and drinking water supply at risk (FAO 1987).

Industrial point source discharges

In addition to this, Ba Town is home to a sugar mill and a number of light industries, which produce significant volumes of pollutants and have some potential for accidental spills (Fagan et al. 1995). Also, the construction of dams and mining contribute to low stream base flows, but dams are not that common in the Pacific and the mining areas in Fiji are not in the vicinity of the chosen areas for this particular case study.

Sectors

Forestry

Approximately 44% (835 000 ha) of Fiji's landmass is composed of natural forest, concentrated in the wetter parts of the country. About 84% of the forests belong to the traditional owners, with the State owning 7% and the remaining being 9% freehold. Extensive areas of Viti Levu and Vanua Levu as well as other smaller islands have suffered severe deforestation; and afforestation and reforestation have been actively pursued since to ease pressure on virgin forest resources. The forestry industry is a big money earner for the Government, raking in over 38 million USD in 1995 (Hasni 2003).

Agriculture

The promotion of economically important cash crops such as ginger, which was cultivated in the Rewa river catchment, led to severe erosion, siltation and massive flooding of cropping land in the lower reaches of the River (Anon 2003).

Urban

There are growing problems in major urban areas (e.g. Suva, Fiji) with respect to supply of potable water and to supply of water to industry. Part of the problem lies in increasing population pressure and is due, in part, to inadequate reticulation and sewage disposal infrastructure. In the Ba River, the presence of a sugar cane mill adds to problems of water supply, and in Suva most industries are concentrated in the peri-urban area, including the Rewa catchment area.

Root causes

Knowledge – Poor public awareness

There is a major need to increase public awareness of issues relating to water shortage and associated problems. This need has been expressed in many reports relating to water use in Fiji (see for example Kaloumaira 2000). The impacts and implications of inappropriate land use are well understood by government, but poorly understood by stakeholders; regulations are also poorly enforced. The impacts of natural phenomena, such as droughts induced by ENSO, for example, have been investigated in detail and the resulting socio-economic effects have been analysed

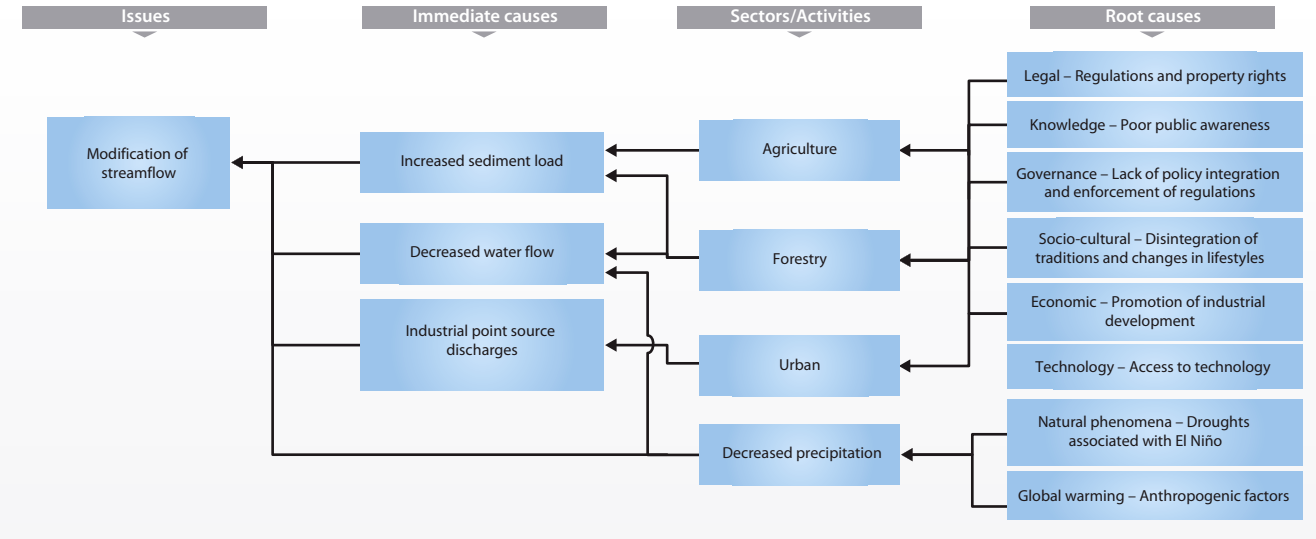

Figure 15 Causal chain diagram for the issue modification of stream flow in Rewa and Ba river basins.

(Kaloumaira 2000). Intensive vegetable growing in the Rewa catchment has resulted in increasing incidences of floods and soil erosion; this is mostly carried out by Chinese-Fijians, who totally depend on their crops for income and security. The apparent abundance of water in Fiji needs to be understood in the context of the growing pressures on supplies, and the need to develop appropriate conservation and use strategies. None of these will work without the full participation of stakeholders who must, in turn, understand the immediate and longer-term impacts of inappropriate water use practices.

Economic – Promotion of industrial development

The government continues to promote industrial developments to ensure a viable economy leading to improving the livelihood of the people. In pursuing these aspirations, compromises are made to allow investors and industries to operate. Some of the great money earning industries for the State includes the agriculture, forestry and tourism sectors. These important sectors have contributed to a high demand on natural resources such as timber and water.

Legal – Regulations and property rights

The majority of the Rewa and Ba basins fall under native title: property rights are proving to be an important issue in Fiji and require a close working relationship between the owners and the government. Regulations relating to water catchments and land use developed by the government will have little effect unless the stakeholders (traditional owners) are party to their enforcement and are part to their development. A consultative process is in place between government and stakeholders, and this must be an on-going and constructive one if sustainable water use is to occur. The important issues include hydroelectric power generation (dams), small-scale agriculture, forestry practices and subsistence farming.

Governance – Policy integration and enforcement

There is a National Code of Logging Practice, and there is a move towards sustainable forest management, but this is inadequately enforced. A multi-disciplinary approach involving a number of different government departments (e.g. Lands, Mining, Agriculture, Forestry, Native Land Trust Board, etc.) is needed for water management. The establishment of appropriate bodies relating to policy and enforcement is recognised in Fiji, and it will be important for this to be effective over the coming years. In a broader context, Fiji is currently developing a national Land Use Policy, which is inter-sectoral in nature. In recognition of catchment management problems, the Fiji Government is now putting more resources into land use issues and there is a section devoted to land and water usage. Fiji has also convened its first inter-sectoral, high level National Water Committee. At the regional level, the GEF-funded and SPREP-implemented International Waters (IW) project includes important strategies addressing freshwater. The establishment of case study sites in selected countries will enable progress towards implementation of the SOPAC Action Plan. It will be important to ensure sustainability of these initiatives once the IW project has been completed, and for other demonstration sites to be identified in those countries where they are not included under the IW programme. Wherever possible, linkages between IW and the SOPAC Action Plan should be developed and strengthened.

Socio-cultural – Traditions and life styles

The Fijian people have long-standing traditional lifestyles centred on their villages, closely related communities (tikina) and the chiefly

system. As mentioned elsewhere in this report, traditional systems are breaking down, and the largely sustainable lifestyle associated with these systems is also in disarray. This has been brought about by the cash economy and urban drift, as well as by population increases. A revitalisation of traditional values and lifestyles could go some way towards sustainable use of water resources, but the impact is likely to be localised and insufficient in terms of the nation as a whole. The use of traditional values will, however, be an invaluable part of the awareness raising aspects of water use.

Natural phenomena – Droughts associated with El Niño

Much has been written about recent El Niño events and their impacts on Fiji (Kaloumaira 2000). The 1997-1998 El Niño event had an unprecedented impact on Fiji, including severe drought. According to Kaloumaira (2000) there have been frequent occurrences of ENSO events in the last three decades (e.g. 1957, 1965, 1969, 1977, 1982, 1987, 1991-1995, 1997), with a negative effect on rainfall (contrasting with a positive effect on rainfall in the intervening La Niña events; 1971, 1973, 1975, 1989, 1996). For example, the 1982-1983 El Niño in Fiji caused the country's worst drought in more than 100 years. This record was surpassed by the drought resulting from the 1997-1998 El Niño, when most parts of Fiji experienced 20 to 50 % below normal rainfall. The impact was especially severe in western Viti Levu, where it affected the sugar cane crop with approximately 25% of the crop destroyed. In addition, it was estimated that losses in the vegetable crop harvest were in the range of 50% during the 1997-1998 drought. According to the Fiji Natural Disaster Profile (n.d.), a total of 263 455 people (i.e. more than 25% of the population) were affected by the 1998 drought. The drought also affected forests growing on thin, poor soils, and increased the incidence of fires. By contrast, access to forests was easier during the drought, thus improving access to trees for logging. Shortages of domestic water supplies were evident in most urban communities, but many of these were more related to delivery systems than actual water availability. In other areas of the western Pacific, there have been up to 87% reductions in rainfall during the past two decades, and 40 atolls in Micronesia have run out of water during an ENSO event (Tutangata 1996).

Global warming – Anthropogenic factors

Global warming has impacts across all sectors in the Pacific Islands. Measurement of its impact on water supplies *per se* is difficult, but with forecast increases in the incidences of El Niño, ENSO and sea surface temperatures, there will be long-term follow-on effects on the small and vulnerable land masses of the Pacific Islands and, ultimately, on water supplies.

Technology – Access to technology and technological trends

Access to appropriate technology and technological trends will be important for managers of catchments and water supplies. The delivery of piped domestic water is limited to urban areas, and many of the systems in place are old and unreliable (leading to the many water shortages, and water wastage, experienced by residents of Suva, Fiji). Water treatment and recycling is inadequate because of costs of the necessary technology; this is causing serious pollution of inshore waters and damage to fragile coral reef ecosystems (and hence the reef and lagoonal fishery). There is limited use of groundwater for irrigation of crops (e.g. in the Sigatoka Valley, where some shallow bores are in use). Water monitoring technology is available but costly. Warning systems for events such as cyclones and El Niño are good, with up-to-date technology available to meteorologists. Disaster management strategies and response mechanisms are in place.

Changes in water table – Bonriki freshwater lens

The site chosen for the case study is the Bonriki freshwater lens, South Tarawa, Kiribati (Figure 16). There is a strong database on this site, which has been intensively studied by a number of agencies, although many of these studies are in limited distribution consulting reports. Bonriki is

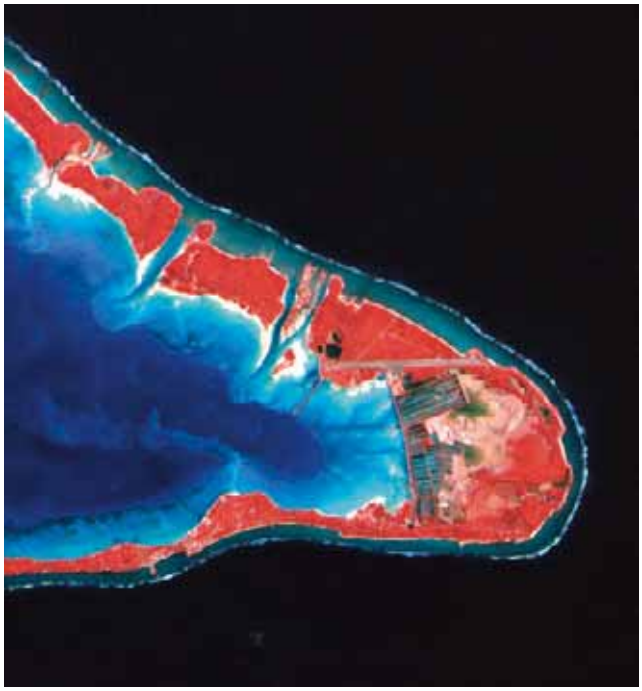

Figure 16 Satellite image of part of Tarawa Atoll, Kiribati.
(Photo: SOPAC)

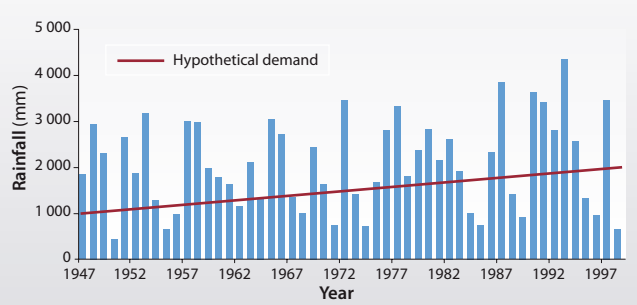

Figure 17 Annual rainfall, Tarawa Atoll and hypothetical water demand, 1947-1998.
(Source: White et al. 1999b)

located at the southeastern corner of Tarawa Atoll, with a population of 35 000. About 35 km in length, the atoll is not more than 1 230 m wide. Rainfall is highly variable on a year-by-year basis, with the most recent figures shown in Figure 17.

This rainfall variation means that periods of drought are not uncommon. Freshwater use per capita per day is 50 l. Bonriki supplies about 75% of the public water for the people of South Tarawa, with a pumping rate (1992) of 1 000 m^3/day (Metai 2002). A reduction of 25% in rainfall causes a 64% reduction in the freshwater lens thickness if pumping rates are maintained at 1 000 m^3/day. The effect of vegetation recharge is such that 80% tree cover would reduce recharge to 35% (Alam & Falkland 1997). It was noted that a single coconut tree disperses approximately 150 l per day.

The main water sources are groundwater, rainwater, and desalination. The water supply coverage is 47%, and access to safe water is 76%, with a total of 25 000 people supplied. The Bonriki freshwater lens is managed by the government (75% of water supply for South Tarawa). There are two other lenses, but these are contaminated by oil (possibly from industrial and/or poorly maintained storage facilities), and this has led to restricted water usage. A difficulty with the desalination plant was that it was built inland, and took some of its water supply from the lens.

The data collected for the Bonriki lens simplify the linkages between the immediate causes and sectors, but the root causes, as elsewhere, are difficult to link. The increased coconut production is leading to increased water use, which in turn leads to saline intrusion. The main concern identified for policy consideration was saline intrusion.

The causal chain diagram for the issue changes in water table in the Bonriki freshwater lens is presented in Figure 18.

Environmental impacts

The environmental impacts include:

- Saline intrusion;
- Up coning and deterioration in groundwater quality;
- Intermittent water supply.

Immediate causes

Excessive pumping

The freshwater lenses on the islands of Tarawa Atoll are up to 30 m thick and the current total pumping capacity of the Bonriki freshwater lens is approximately 1 000 m^3/day (Falkland 1992). The increased demand for water from the Bonriki and Buota lenses has led to excessive pumping which, in turn, reduces the capacity of the lens and puts extra strain on the resources. As a consequence, the authorities had placed restrictions on water use.

Reduced recharge from decreased precipitation

Extended low rainfall periods in 1998 and the early part of 1999, particularly in South Tarawa may have contributed to the dramatic increases in salinity in domestic wells, the death of some trees, die-back in others, rainwater tanks running dry and an increasing demand on potable, reticulated water (White et al. 1999a, b).

Sectors

Agriculture

Excessive pumping by the agricultural sector contributes to changes in the water table. Copra continues to be an important money earner for the national economy accounting for up to 62% of exports (Falkland 2001), which means the growing of coconut trees is encouraged. Moreover, subsistence farming through the planting of other food crops such as breadfruits, pandanus, pawpaws, bananas and swamp taros all contribute to the consumption of water. As stated previously a coconut tree is capable of consuming up to 150 litres of water per day, which is as much as a household of five people (White et al. 2000).

Urban

The high population growth rate in urbanised South Tarawa is attributed to both increased births and immigration of outer islanders. Furthermore, illegal occupation of water reserve areas is exacerbating the declines in the quality of the water supply with early indication of water pollution attributed to on-site developments. This factor, together with the inadequate facilities and infrastructure (e.g. poor utilisation of rainwater tanks) available, all place demands on the water supply system that exceed the system design specifications (Tebano 1996, Crennan 1998). Moreover, illegal connections, reticulation

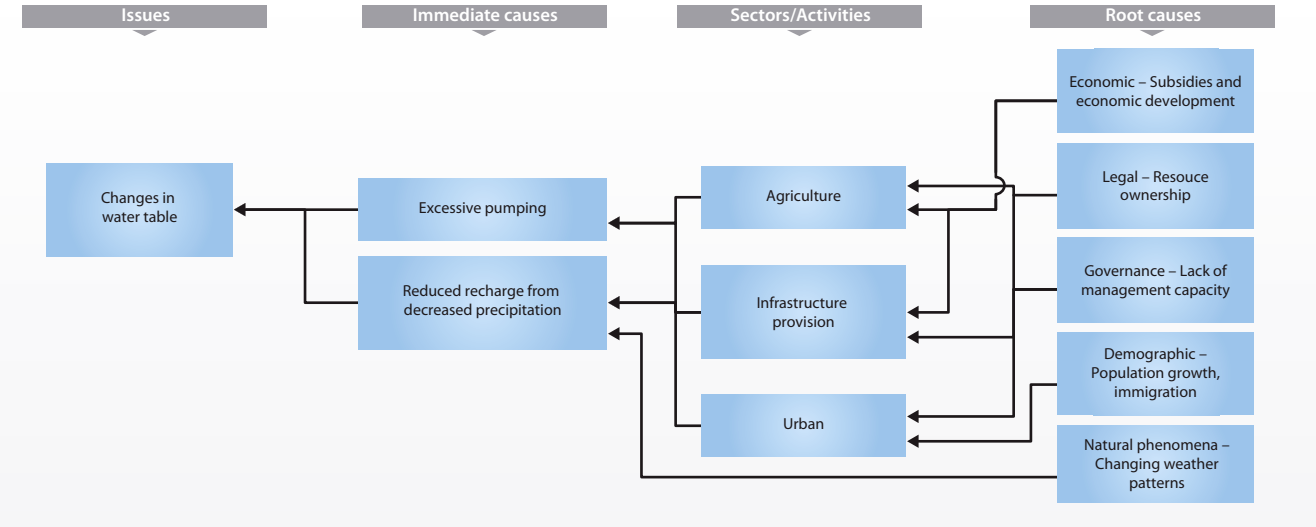

Figure 18 Causal chain diagram for the issue changes in water table in Bonriki freshwater lens.

leakages and water wastage have resulted in the intermittent supply from the reticulated water system (Falkland 1992).

Infrastructure provision

The current infrastructure that is employed at the two water lenses (Bonriki and Buota) consists of 24 galleries (18 at Boniriki and 6 at Buota). These galleries consists of 300 m long slotted PVC pipe laid below the water table and pumping approximately 55 m^3/day. Continuous pumping is maintained to minimise the impact of the pumping on the water lens (Metai 2002). The public water supply has been unable to meet the demand due to high losses (50% leakage) in the distribution pipelines (SOPAC, in Metai 2002).

Root causes

Legal – Resource ownership

Issues concerning the ownership of the land in which the water lens exists must be addressed. Parts of Bonriki have been reserved for the airport and to supply water for the public. Conflicts have arisen as traditional owners become suspicious of the Government on the use and compensation of their land (Crennan 1998).

Demographic – Population growth and immigration

The inundation of urban areas through immigration from outer areas in search of better opportunities is a significant root cause that has a cascading effect on the natural resources. This needs to be addressed immediately by the government and traditional leaders.

Economic – Subsidies and economic development

The cost for operation and maintenance of water supply is approximately 1.44 USD/m^3, whereas the current water tariff stands at 0.80 USD/m^3. This unsustainable level of operation, despite government subsidy, will continue to plague water availability to the people unless serious actions are adopted to curtail this practice. It would seem that the subsidy might create a sense of security to users, and lessen any tendencies to economise.

The planting of food crops and economically marketable crops will no doubt be encouraged as part of the government's development initiatives. These necessary developments and initiatives come at the expense of available potable water to the people.

Governance – Lack of management capacity

The capacity to manage water supply needs to be addressed as the current scenario has failed to curb illegal connections, leakages and water wastage.

Natural phenomena – Changing weather patterns

The severe weather pattern experienced in 1998 and 1999 has impacted significantly on the water availability to the community. The World Bank estimated that the climate change impacts on the groundwater are costing 1.4 to 2.7 million USD per year (Metai 2002). Alam and Falkland's (1997) computer simulation model indicated that any changes in the rainfall would have a significant impact on the freshwater lens. The combination of factors such as decreased rainfall and rising sea levels will have a catastrophic effect on the freshwater lens and consequently the people.

Unsustainable exploitation of living resources

The case study on the unsustainable exploitation of living resources focused on Fiji, specifically in Lau, Kaba, Lami, Denarau and the Suva Lagoon areas (Figure 19), where relevant studies have been made and some data are available. The issues identified for these sites in Fiji have a wider application in the region, especially in areas where similar fishing activities are undertaken.

The causal chain analysis was carried out on the following priority issues:

- Overexploitation of living resources;
- Destructive fishing practices;
- Decreased viability of stocks.

The unsustainable exploitation of fish and other living resources is increasingly becoming a negative feature of fisheries development where there is now a characteristic boom and bust pattern. This feature is the result of factors such as the need to maximise income and involvement in fisheries activities. There is increased effort by fishers to fish rapidly declining resources with undesirable consequences. In addition, destructive fishing methods are frequently used as people attempt to meet their own commitments. Regrettably, fish populations are declining due to overharvesting and the modification of their ecosystems (Pauly et al. 2001).

Coastal communities that have relied on their coastal fisheries resources for centuries are finding their catches dwindling. More often their catch is now for people other than themselves (such as for family commitments, or for income to support family and church activities). Market forces are making people desire more thus providing incentives to fish more using newer and more efficient fishing equipment. This is evidenced in major urban centres such as Suva, Lautoka and Labasa and surrounding areas, where mullets and reef fishes are depleted (Johannes pers. comm.). The unsustainable exploitation of living resources is a concern in the Pacific Islands, and the impacts are both socio-economic and environmental.

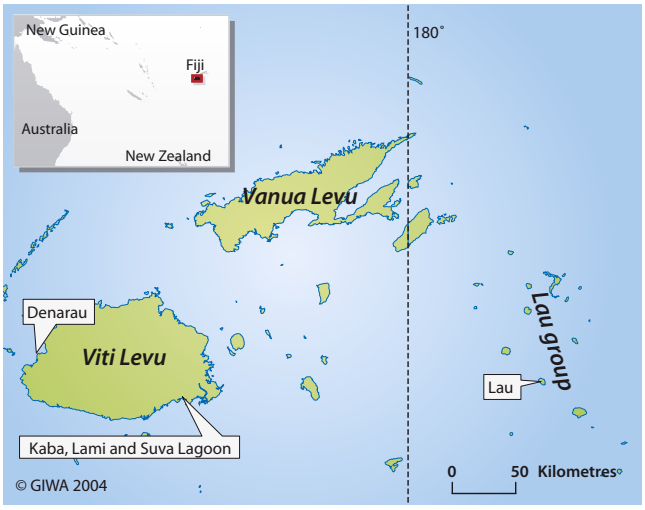

Figure 19 Fiji Islands.

Overexploitation of living resources

The causal chain diagram for the issue overexploitation of living resources is presented in Figure 20.

Environmental and socio-economic impacts

The following environmental and socio-economic impacts were identified:

- Loss of employment/income (Veitayaki et al. 1995);
- Loss of income capacity (Dalzell et al. 1996);
- Changes in food web (Jennings & Polunin 1997);
- Depletion of key species (Fiji Fisheries Division 1995, 1996);
- Reduction in size of fishes sold at markets (Lal pers. comm., Fiji Fisheries Division 1995, 1996).

Immediate causes

Increased effort

The Fiji Fisheries Division Annual Reports (1995, 1996) highlighted a decrease in catch per unit effort as well as a steady decline of fish sales at municipal markets (11% in 1996 compared to 40% in 1981), with the central division (Suva) being considerably impacted. A recent trend shows that the Suva and Lautoka markets are increasingly selling fish shipped from remote places such as Labasa and Ba.

Rural migration to urban centres by indigenous Fijians searching for better opportunities leads to a high demand for fish in urban areas (Jennings & Polunin 1997). Consequently, the price of fish increases due to the demand providing more incentives to increase fishing effort (Fiji Fisheries Division 1992). Such increases in fishing effort can be demonstrated by a study of the Astrolabe reef where giant clams

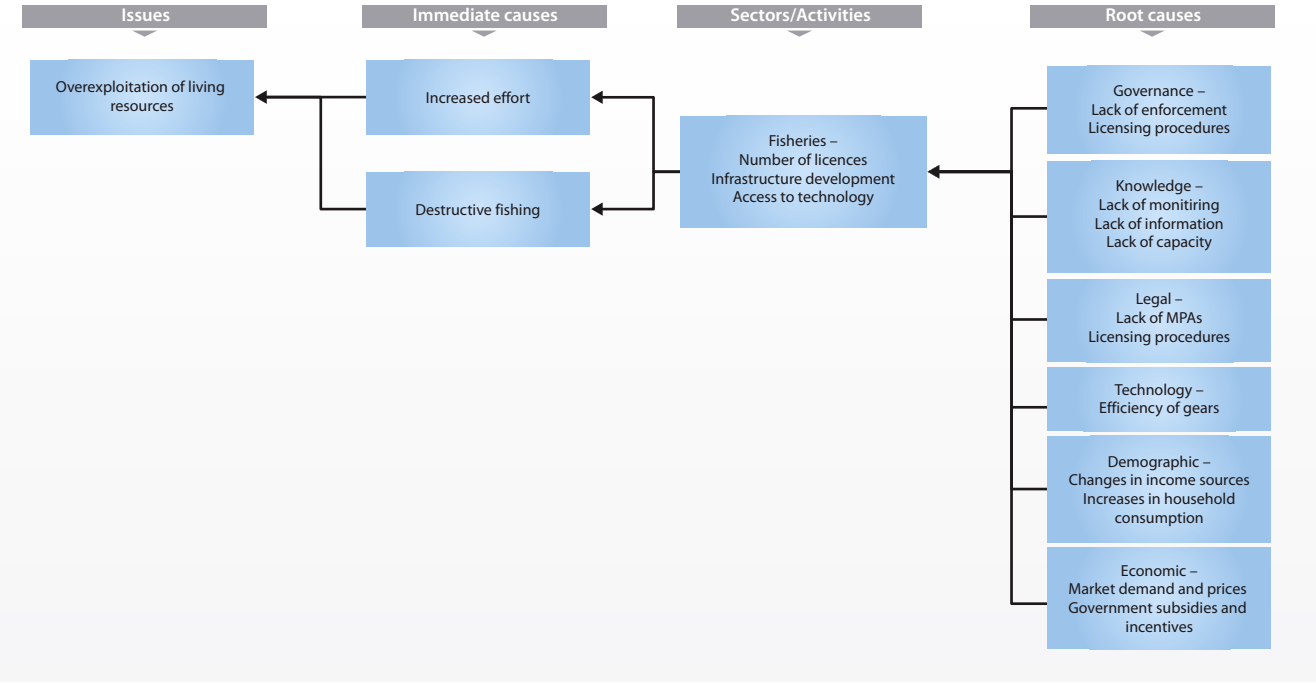

Figure 20 Causal chain diagram for the issue overexploitation of living resources.

and trochus declined rapidly. The reef fisheries in accessible sites have been exploited to meet existing subsistence needs and to supply the demand from urban markets (Rawlinson et al. 1995). This has led to an increase in the artisanal fisheries sector fishing in remote places as traditional fishing sites become decimated (Figure 21). The scenario is widespread throughout Fiji and is documented by the Fiji Fisheries Division's annual reports.

Destructive fishing

Overexploitation of fish is also attributed to the use of destructive fishing methods, such as explosives, modern poisons (cyanide, bleach, pesticides), physically destructive practices (fish drives, manual breaking of corals), traditional poisons (plant and animal compounds that stun or kill fish), and other methods that lead to the overharvesting of one or more species (Veitayaki 1990). Gill nets are blamed for the overexploitation of fish in many parts of Fiji (Veitayaki et al. 1995). Of concern is that many of these methods are not only destroying the environment and the fisheries but they are also a danger to the user. The availability of dynamite to fishers in Votua, Ba worsens the situation (the dynamite is stolen from the local mining operations), and is coupled with the fallacy that dynamite fishing is less destructive than gill nets. Newer industries such as the ornamental and aquarium trades being undertaken along the Coral Coast are enticing some fishers to earn 'quick cash' (Sykes pers. comm).

Sectors

Fisheries – High number of licenses issued

Licenses are put in place to control the entry into the fisheries. Unfortunately, licensing has not been as effective as it was hoped. The number and condition of licenses offered lack scientific input and is offered to all those who can pay. This is a serious problem in the inshore fisheries where there is little knowledge of the stocks. The increase in the number of licenses within the inshore fisheries relates to the number of people using the fisheries. Government policy has promoted the development of fisheries (of commercial nature) outside demarcated areas, to allow the subsistence fishery to harvest inshore resources. The international live coral reef fishery, which usually fetches higher prices than local markets, is providing extra pressure, as local communities are enticed to participate. In the area of offshore fisheries, the debate on the number of licenses has also featured in local media in recent times. The fishing industry and the Fisheries Division have disagreed on the number of fishing licenses that should be issued. The industry feels that the 80 licenses that have been issued are excessive. The Fiji Government continues to issue licenses in the hope of stimulating economic growth (Bolatiki 2002).

Fisheries – Access to technology

Technological change has been evident within the inshore and offshore fisheries throughout the world. With the desire for more catch, people are investing in more efficient fishing gear that allows them to access fishing grounds further afield. Outboard motors and

motorised vessels are a case in point, where fishers are able to travel far in a considerably smaller amount of time. The availability of ice and storage facilities prolonging the freshness of the catch is another milestone in the technological development of the fishing sector. The use of underwater breathing apparatus (SCUBA and Hookah) has made fishing so efficient that it threatens the survival of the fish stock. Night fishing using underwater torches is another technology that is most probably affecting the fish stocks.

Fisheries – Infrastructure development

With the emphasis on rural development and decentralisation, infrastructure development has been rigorously pursued. New roads, jetties, airstrips and processing facilities have been provided in rural areas and outer islands. These new developments have not only stimulated intensive utilisation of fisheries resources, they have also introduced market economy and consumerism to remote places. There is also increasing pressure to access lucrative export markets for high-value species. The availability of electricity is associated with the introduction of electrical goods such as television, refrigerators, CD players and stereos. Changes within communities are inevitable as modern goods replace 'traditional' wares when cultural activities are pursued. For example, fishes, pigs, taro and other natural resources were used during cultural celebration. These items are more or less substituted for cash, cloth, tin goods and other dry goods (e.g. rice, flour, sugar). This consumerism may provide incentives to sell more fishes in order to provide electrical goods.

Root causes

Governance – Lack of enforcement

Enforcement is an essential element of fisheries management, which is inadequately executed in Fiji. The use of destructive fishing methods and unsustainable fishing practices such as the harvesting of undersized fish will continue unabated attributed to poor enforcement. Moreover, the undersized catch is freely sold at the market where again poor enforcement may be encouraging this practice. Coupled with the lack of enforcement is the serious need to address the adequacy of current legislation. Furthermore, public education and awareness must be part of such a legislative campaign to thwart illegal and destructive fishing activities.

Governance – Licensing procedures

The licensing system in Fiji is far from adequate. In the inshore fisheries, all commercial operators are licensed (Table 9), however, traditional owners are excluded, and an open access system prevails.

Figure 21 Foreign fishing vessels at Suva Harbour, Fiji.
(Photo: G.R. South)

Table 9 Number of licenses, middlemen, total crew and vessels in Fiji 1995 and 1996.

Division	IDA*	ODA**	Middle men***	Total crew	Vessels
1995					
Central	246	55	84	741	351
Western	572	18	18	1 628	586
Northern	688	83	42	1 272	540
Eastern	43	19	9	185	68
Total	1 549	175	153	3 826	1 545
1996					
Central	232	97	80	768	448
Western	514	13	-	1 241	513
Northern	605	83	71	1 197	539
Eastern	46	40	5	226	96
Total	1 397	233	156	3 432	1 596

Note: Vessel number = inboard, outboards, punts and half-cabins, excluding un-powered.
** IDA = Inside Demarcated Area (customary fishing right); **ODA = Outside Demarcated Area; ***Middlemen = People involved in marketing only. Also note, Lau province, which has relatively rich fishery resource, has stopped issuing commercial fishing licenses as requested by the Tui Nayau including bait fishing.*

(Source: Fiji Fisheries Division Annual Report 1995,1996, 1997)

The licensing procedure operates on a who-can-pay system. Once the license is issued, fish catch becomes dependent on labour and the carrying capacity of the fishing vessel. Rarely is the fisheries legislation enforced due to inadequate resources. These open systems (commercial after obtaining a license and traditional clan access) can lead to overexploitation and it may take a while before the endangered stock is detected by the authority. Thus, it becomes paramount that a mechanism is identified where the authority is alerted on overexploited stocks as soon as it can be detected. In coastal communities, fishing is permitted provided they do not sell their catch. In the commercial sector, the licensing issue remains contentious between those who want to regulate the number of licenses issued and those who want more licenses issued.

Knowledge – Lack of surveys/monitoring

Surveys and monitoring are vital to complement fisheries management measures (Veitayaki 2001). There is a need for monitoring and survey methods to be simple and relatively cheap, to allow developing countries to participate fully. Currently, some surveys and monitoring methods require certain scientific knowledge, which may be beyond the capacity and capability of countries such as Fiji. The knowledge of Fiji's subsistence fisheries is currently based on a household study conducted in the early 1990s. Prior to this survey, the contribution of the subsistence fisheries to the local economy was based on an annual increase of 200 tonnes that is added on to a figure that was formulated in 1978. In the tuna fisheries, maximum sustainable yield (MSY) and total allowable catch (TAC) are used but these are based on estimates that may have little bearing on the way the fisheries were utilised. Monitoring is now being used to demonstrate the recovery of the fisheries resources as a result of management intervention.

Knowledge – Lack of information and capacity

Knowledge of fisheries resources is still inadequate. Managers need more information on the resource status and the impact of fishing activities to the stock. In the Pacific Islands, the mandated government agencies for managing fish stocks such as the Fisheries Divisions are implementing strategies to manage fish stocks that they do not know enough about. This is a serious situation, which can only be addressed with better research and capacity building. In the areas of tuna fisheries, the belief at the regional level is that the stock in the region is still under-utilised but at the national level, the fishers are arguing that overexploitation is already a problem.

Legal – Lack of MPAs

Marine protected areas (MPAs) are being used as a fisheries resource management tool. Often when and where the science is unable to provide the information required for management decisions, MPAs have been used as a precautionary method to reduce fishing effort in an area. The goal of such action is to allow for the recovery of the fisheries. There is little documented evidence that MPAs have worked in the Pacific. In most cases, MPAs have not worked, probably because the concept is foreign to some local communities. In general, MPAs require people to protect the resources over a period of time, and in some cases, permanently. The area included within MPAs, coupled with closure periods, which could infringe on traditional fishing grounds, may be part of the problem in accepting and implementing MPAs. In some cases, donor driven MPAs and interference from outside factors (e.g. government, NGOs) may make the approach difficult to implement despite the close relation to the customary practice of periodically declaring tabu areas (Veitayaki 2001).

Technology – Efficiency of gears

Fishing technology has changed dramatically over the last 20 years. In spite of all the attempts to foster sustainable fisheries, the efficiency of gear and the capacity and aspirations of the fishers to catch more, is proving to be an obstacle that needs to be addressed.

Demographic – Changes in income source and increases in household consumption

Fishing is not a difficult pastime and with open access, everybody can fish. The availability of fishes and shellfishes to communities

makes it their main source of protein (Veitayaki 1990). In 1996, the fish consumption per capita was around 55 kg (Fiji Fisheries Division 1996). Consumption levels are even higher in some other Pacific Island countries, perhaps as high as 200 kg/person/year in Kiribati (Dalzell & Adams 1996). The increased demand for fish is creating competition for limited resources, and increases in the sales of undersized fish. The easy access to the ocean and often the promises of return from selling the catch make fishing an attractive source of income and livelihood (Veitayaki 2001). Moreover, stories of people becoming rich due to fishing businesses are enticing more people to the industry.

Economic – Subsidies and incentives

The Fiji Government sees in fisheries the opportunity to improve the economic position of its people and to stimulate growth within the country. This is why fisheries development is pursued at various levels, such as the different licenses issued to commercial, recreational and industrial fishers, coral harvesters, and aquaculturists. Furthermore, policies on the development of rural communities and islands are often associated with incentives such as free or subsidised outboard motors, fishing nets and punts, without considering the consequences of these policies. In the foreseeable future, the government will continue its push to assist rural communities. This may include improving infrastructures such as road and building facilities to enhance the fisheries sector (e.g. ice-machines). Unwittingly, this may lead to the overexploitation of fish, as rural fishers succumb to urban market demands.

Subsidies and taxes are part and parcel of the national attempts to maximise the production and return from the use of the country's fish resources. Incentives to entice investors to Fiji include attractive terms and conditions. Subsidies are also available for the inshore fisheries sector. Special loans from the Fiji Development Bank have been formulated and subsidised petrol provides further incentive to invest in the fisheries industry. It must be acknowledged that the push for fast investment projects, especially those along the coast, may result in negative impacts on the marine environment.

Economic – Market demand and prices

The demand for fish and fisheries products in any urban area is immense. Fishers are encouraged to take advantage of the opportunity to earn a good income and tend to use effective fishing methods regardless of their impact to the fish stock. The Suva municipal market today is filled with assorted reef fish of variable sizes. The laxity in enforcement, the high demand for fish, coupled with very attractive prices, are driving fishers to overexploit the precarious resources. Gone are the days when a string of good-sized mullets was only 2.5 USD. Today, a string of fish (5 fishes per string) is often more than 5 USD, yet consumers buy it. Restaurants around Suva demand a high quantity of seafood with very lucrative prices, thus driving more fishers to catch as many fish as they possibly can.

Destructive fishing practices

The causal chain diagram for the issue destructive practises is presented in Figure 22.

Environmental impacts

The environmental and socio-economic impacts identified were:

- Damaged fish sold at market;
- Absence of targeted fishes such as mullet (*Mugil* spp.);
- Habitat destruction;
- Injuries to fishers.

Immediate causes

Blast fishing

Although dynamite or blast fishing is illegal in most Pacific Islands, it remains a commonly used method for catching fish. It has been used in American Samoa, Chuuk, Fiji, Marshall Islands, Micronesia, Palau, PNG, Solomon Islands and Samoa (Veitayaki et al. 1995). In Fiji, dynamite is used to catch Salala (Short mackerel, *Rastrelliger brachysoma*) for sale or

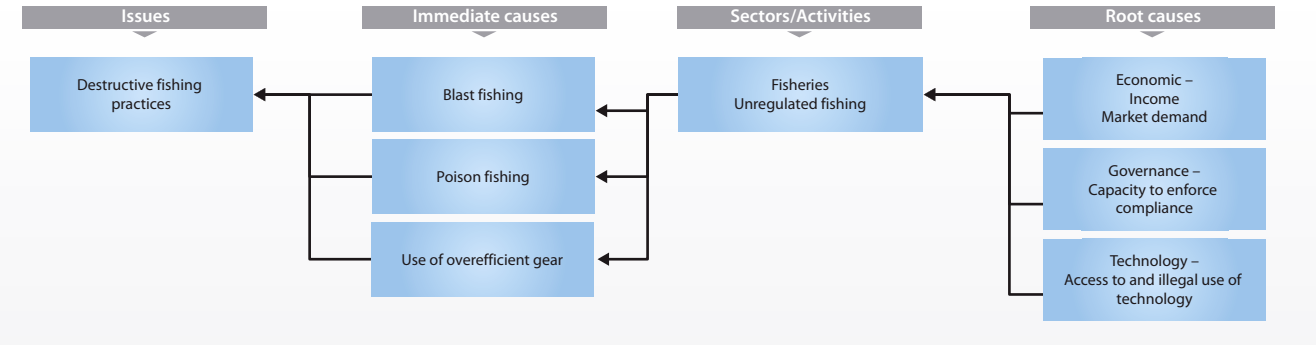

Figure 22 Causal chain diagram for the issue destructuve fishing practices.

for bait. Blast fishing is very destructive to the fisheries and the marine environment. Demersal plankton production is decreased in blasted areas leading to reduced food supply to fish. The number of people who have lost their lives or parts of their bodies to dynamite fishing demonstrates the seriousness of the problem.

Poison fishing (duva, chlorine, cyanide)

The use of traditional poisons is common in Fiji and the Pacific, especially chlorine, cyanide and duva (this is the poison root that makes for an easy harvest, but kills all small fish and corals as well as the larger target fish). A number of plants are used by villagers to poison and stupefy fish at nearby reefs (Table 10). In addition, chlorine and other similar chemicals are used in rivers, whereas cyanide is commonly being used to catch specimens for the aquarium and live fish trades. The use of poison is destructive, as it not only affects the target fish species; it also impacts negatively on the fishing area and the fishers.

Use of overefficient fishing gear

Fishing is becoming more efficient with the use of sophisticated gear. In the inshore area the widespread use of gill nets is blamed for the depletion of fish stocks (Veitayaki et al. 1995). People are using modern technology to be free of the vagaries of nature and the uncertainty in fishing.

In the offshore areas, walls of death (drift-nets) were first banned from the Pacific Ocean under the Wellington Convention (1989), which has become the basis of the current UN moratorium on driftnet fishing. The involvement of factory vessels and sophisticated fishing vessels such as purse seiners are indicative of the sophistication that is associated with fishing and the depletion of fish stocks.

Table 10 Plants used as fish poisons in the Pacific Islands region.

Scientific name	Parts used	Description/Notes	Areas used
Barringtonia asiatica, B. speciosa	Seed	Tree; active compound is saponin.	A. Samoa, Fiji, Futuna, French Polynesia, Guam, Vanuatu
Derris elliptica	Root, bark, stems	High-climbing woody liana. Roots contain rotenoids, the most potent of which are rotenone and tephrosin. It was introduced from Asia to the Pacific and is commonly cultivated for rotenone production.	A. Samoa, Fiji, Kosrae, New Caledonia, Tahiti, Tonga, Guam, PNG, Palau, Vanuatu, Samoa
Euphorbia cotinifolia, E. canadensis, E. tannensis	Stems, leaves		Fiji, New Caledonia
Neubergia collina	Fruit	Steamed fruit is mixed with water.	Fiji
Pittosporum arborenscens	Fruit	Cooked first.	Fiji, Tonga
Tephrosia piscatoria	Leaves	Perennial herb.	Cook Islands, Hawaii, Fiji, Tahiti, Moorea

(Source: GIWA Task team 2004)

Sectors

Fisheries – Unregulated fishing

There are three main issues that need to be regulated in order to contribute meaningfully to the management of the fisheries resources, including:

- Fishers: permitting too many fishers to fish in a given area will lead to resource depletion;
- Fishing method: destructive and overly efficient fishing methods must be banned;
- Fish catch: ensure that fish catches (especially those offered for sale) conform to set standards. Gravid crustaceans and undersized fishes must not be harvested let alone offered for sale.

It is recognised and understandable that the subsistence fishery is not regulated, as often families harvest sufficient quantity for their sustenance. In the commercial sector, it is acknowledged that the higher the catch, the higher the return; hence operators are driven to catch more. It is in this sector that regulations must be enacted. Illegal fishers will capitalise on low enforcement and inadequate laws; this must be addressed. Encouraging local coastal communities to participate in the management of their resources, for example by harvesting just what they need, and by reporting instances of illegal fishing to the authorities must be pursued.

Root causes

Economic – Income

The need to generate income to support family needs has prompted many fishers to drive the coastal/near-shore fisheries to depletion. While other sources may provide a steady income, fishing appears to be more lucrative and with little preparation and investment. For example, a farmer left farming for fishing because his income from farming could not cater for his children's school needs (Veitayaki et al. 1995). People who lose their jobs often take up fishing because of its open-access and the lack of control.

Economic – Market demand

In Pacific Island urban areas, the market demand for fish and fisheries products is high. Fishers sell their catches directly to consumers, middlemen, wholesalers, retailers, restaurants and hoteliers. Such demands have led to excessive exploitation in areas that were once considered productive. The exploitation of other commodities such as fish for the live food and aquarium trades, adds to the pressure on the vulnerable stocks. People are moving from one commodity to another and in the process leaving behind barren areas.

Governance – Government capacity to enforce compliance

The Fiji Fisheries Division is charged with the responsibility to manage Fiji's fisheries resources according to the mandate stipulated in the Marine Spaces Act (Fiji Government 1985) and the Fisheries Act (Fiji Government 1978). The vastness of the Fiji Islands coupled with low capacity makes it difficult for the Fisheries Division to manage the fisheries resources (Veitayaki 2001). This has lead to continuing illegal and unregulated fishing in many parts of the country. Moreover, the costs of enforcement are overwhelming and the requirements in terms of technology are beyond reach. Although Australia has provided Pacific Class Patrol Boats, their high costs of operation has meant that surveillance by the patrol boats is rarely carried out. For these reasons, the country needs to formulate better and more effective ways of enforcing its regulations. The vessel monitoring system used in the EEZ using GPS and observers is an example of a cheaper alternative.

Technology – Access to technology

In Fiji, the continued availability of explosives is the subject of much debate. People associate the availability and use of dynamite with the operation at the gold mine in Vatukoula (Veitayaki et al. 1995). This position is disputed by the Emperor Goldmine, which argues that its security system is fool-proof and that the company cannot be solely blamed for the availability of explosives to fishers. Incidentally, dynamite is also used in the construction industry and these likely sources should be more tightly scrutinised. The use of explosives in places such as American Samoa where there are no mining activities should support the need to look closely at the supply of dynamite and other illegal technology.

The use of technology has enhanced people's fishing capability. People are now able to fish at greater distances over a longer period. The use of outboard motors, for example, has allowed people overcome the forces of nature that used to be a limiting factor in past fishing expeditions. The introduction of rural development initiatives through provision of boats, outboard motors and new fishing technology to improve peoples living conditions is allowing them to increase production. The availability of depth sounders, fish finders, monofilament nets and hydraulic winches has increased the potential of catching fishes and at the great expense and unfairness to the fish stocks.

Decreased viability of stocks due to pollution and disease

The causal chain diagram for the issue decreased viability of stocks due to pollution and disease is presented in Figure 23.

Environmental impacts

The environmental impacts identified were:

- Imposex - sex modification in gastropods (Tamata et al. 1993);
- Change in water quality;
- Presence of unnatural substances and pollutants;
- Fish diseases.

Immediate causes

Increased concentrations of Tri-butyl tin, copper and creosote

Studies have demonstrated that sub-lethal contamination by common estuarine pollutants can significantly alter innate immunological reactions in tunicates (Rice 2001). The three compounds, Tri-butyl tin (TBT), copper, and creosote are major components of antifouling films that are used to prevent the growth of sessile invertebrates and other

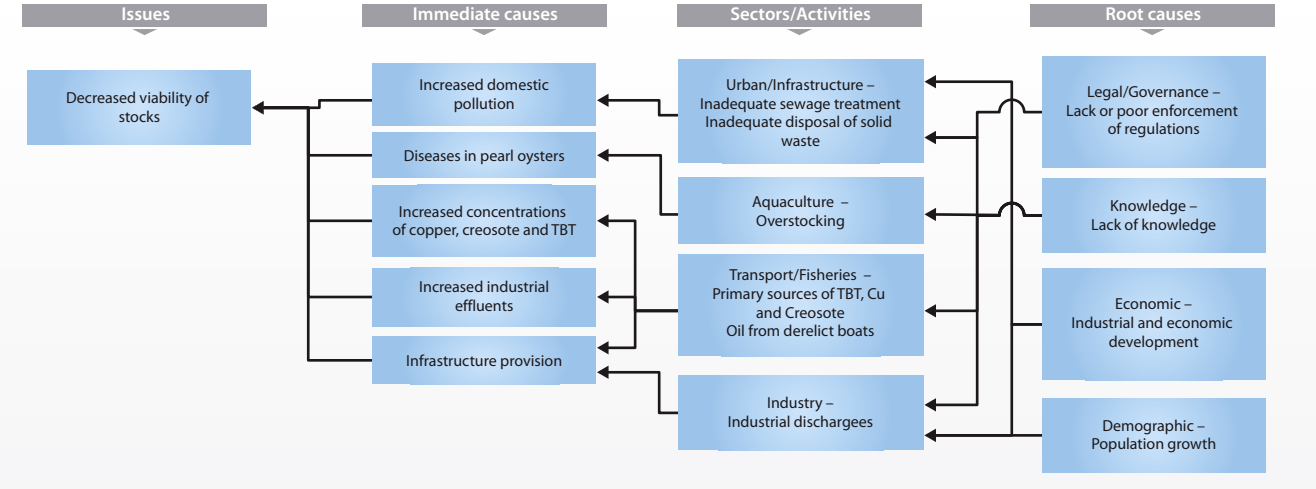

Figure 23 Causal chain diagram for the issue decreased viability of stocks due to pollution and disease.

organisms. TBT concentrations of more than 2 µg/l have been detected in marine areas and can leach from marine paints and accumulate to hazardous levels in harbours and marinas (Bryan et al. 1986). Studies conducted in Suva have indicated the contamination of sediments and shellfish from trace metals. There were claims that elevated levels of TBT were already causing imposex in female neogastropods around Suva (Tamata et al. 1993). The highest concentrations of TBT were from sites nearest to the slipways. Increased levels of TBT are correlated with gradual population decline and increased imposex in gastropods (Rilov et al. 2000). In addition, it is known to inhibit chemiluminescence responses, chemotactic activity, phagocytic oxidative bursts and phagocytosis by fish leukocytes (Weeks & Warinner 1984, Weeks et al. 1990, Burton et al. 2002).

Like TBT, copper is known to have substantial immunological effects on aquatic organisms at sub-acute doses.

Creosote is a hydrocarbon-based protective coating that is frequently used on pylons, wharves, and netting. Polycyclic aromatic hydrocarbons (PAHs) in particular have been associated with a variety of physiological effects including carcinogenesis and the alteration of immune reactivity in humans and other animals (Rose et al. 2000). In fish, PAHs are responsible for the development of eye lens cataracts, gill necrosis, degeneration of renal epithelia, and neoplasia. They can also inhibit macrophage function, cellular cytotoxicity and cellular proliferation. PAH levels greater than 10 times the maximum dose are reportedly common for harbour waters, and levels of copper up to 2.5 µg/ml have been detected in heavily utilised environments.

Diseases in pearl oysters

In 2001, there was an emergency scenario from Manihiki Atoll in the Cook Islands when oyster mortality from a disease was unprecedented and attributed to overstocking oysters (Sharma et al. 2001, Solomon 1997).

Increased industrial effluent

The concentration of oil in the effluents from some of the industries in Walu Bay was found to exceed the maximum permissible level. Concentrations of dissolved solid and suspended solids were very high whereas the levels of zinc and lead were extremely high. Reproduction in the polychaete *Neanthes arenaceodentata* was affected by the presence of PCBs (Poly-Chlorinated-Biphenyls) and DDT (Dichloro-Diphenyl-Trichloroethane). In addition, biomagnification results in the accumulation of large concentrations of heavy metals such as mercury in carnivorous fish such as swordfish (*Xiphias gladius*). Heavy metal or polychlorinated biphenyl contamination in worms can significantly inhibit lysozyme activity, wound healing, phagocytosis, rosette formation, and tissue transplantation rejection at concentrations that are not acutely lethal (Weeks et al. 1990).

Increased domestic pollution

The release of effluents into Laucala Bay from the greater Suva area is blamed for the high nutrient levels and organic enrichment (Naidu et al. 1991). Both the Raiwaqa sewage treatment plant which discharges into the Vatuwaqa River and the Kinoya sewage treatment plant discharging via an 800 m pipe into the Laucala Bay are known sources of faecal coliform in the area. There are also leachates coming from the municipal rubbish dump in Lami.

Naidu et al. (1991) found high faecal coliform levels, high nutrients (nitrate and phosphorous), and trace amounts of cadmium in Suva Lagoon. Shellfish sample analysis indicates a potentially hazardous situation with only 5% of the results falling within recognised safety limits. Infaunal brittle stars increased somatic and gonadal growth in response to organic enrichment. Negative effects were observed on the survival of mysids (*Mysidopsis bahia*) when essential ions such as calcium, magnesium, and potassium were present in either low or high concentrations relative to natural levels in seawater. Tolerance ranges for calcium, magnesium and potassium shifted significantly with changes in salinity.

Infrastructure provision

The Port of Suva serves as the main port of entry for overseas cargo and passenger vessels coming into Fiji. The Port of Suva also serves as a trade link between Australia, New Zealand, North America and the countries of the South West Pacific. The port of Suva in 2001 handled a total of 1 301 356 tonnes of cargo of the total amount of 2 703 403 tonnes for the country. This domination reflects the importance of the port to the national economy. In 2002 and 2003, major development works were been undertaken in the ports of Suva and Lautoka. Port developments often involve coastal developments, which are expected to affect coastal habitats and the resources within the area. The anticipation of the Suva Port to cater for larger vessels means more coastal developments including coastal reclamation to cater for such plans.

Sectors

Aquaculture

With increased overstocking and decreased levels of oxygen, pearl oysters are faced with a dilemma. Sharma et al. (2001) concluded their water quality study with recommendations that: a) a limit on the black-lip pearl-oyster population needs to be determined to safeguard the lagoon's carrying capacity; and b) continuous monitoring of

the lagoon's water quality needs to be implemented to protect the industry from outbreaks of disease in cultured oysters. This problem is expected to become increasingly important given the interest in aquaculture activities.

Industry

Apart from sedimentation, the major sources of pollution in the Port of Suva are sewage and industrial effluents. These sources are directly related to the growth of the urban economy and the impacts that growth has on the surrounding areas. In a study conducted in 1992, 14 industries in the Walu Bay area were found to be discharging their effluents either directly into port waters or into a river or into stormwater systems, ending up in the bay.

Transport/Fisheries

Old and unused ships and yachts have been a cause of concern in the Bay of Islands, which has become the graveyard for vessels. These vessels are a threat to marine life around the area because oil leaks are a likely eventuality.

Although the use of TBT on pleasure craft is now prohibited and is being replaced with copper-based antifouling products, it is still applied to larger vessels. It remains a common harbour contaminant

Urban/Infrastructure

The primary source of sewage effluent into Suva lagoon is the outfall from the Kinoya sewage treatment plant. The plant, which serves the entire city, is badly overextended. It discharges through a pipeline into Laucala Bay where poor circulation in the shallow bay is affecting the dilution of the sewage. The result is the highest concentration of faecal coliforms in Laucala Bay and Suva Lagoon.

The use of septic tanks in parts of Suva Peninsular adds to the problem as sewage leaks into creeks and rivers that end up in the bay. The problem is serious because of the location of the city on calcareous marl that limits percolation into the ground. The present dump in Lami is a mountain of rubbish that continues to increase. The smell is intolerable whereas the contamination of the site and surrounding areas is a serious concern. Attempts to relocate the dump have not been successful resulting in the continued use of the present facilities.

Root causes

Legal/Governance – Lack or poor enforcement of regulations

The use and management of environmental resources around Suva is exacerbated by the lack of information and lack of regulations. People and industries pollute their surrounding because the system does not enforce the regulations or because there are no regulations to protect these ecosystems. Coral reefs and other habitats such as mangrove forests and seagrass beds are increasingly degraded by the unregulated development and the utilisation of coastal resources.

The major sources of elevated nutrients to coastal waters are typically from human waste and chemicals. Immediate action is required at the community, regional and governmental levels to reduce the nutrient inputs into the marine environment where an integrated management approach is needed to manage and control land-based sources of pollution before they enter the sea.

Knowledge – Lack of knowledge

Lack of knowledge has been a limiting factor. With research and long-term monitoring now undertaken, people are beginning to understand the natural system and how it functions. The use of the precautionary approach is seen as an alternative to humans' lack of knowledge of the natural world and how it works. Human knowledge has to improve if better environmental management is to take place.

Demographic – Population growth

Suva is a major commercial centre and is a rapidly expanding city in terms of population and industrialisation. The increase in Suva's population from 80 000 in 1966 to 160 000 in 1986 (Naidu & Morrison 1994) and about 168 000 in 1996 (Seniloli pers. comm.) with the associated industrial development, port activity and waste generation has resulted in considerable environmental changes within the coastal area of Suva. The developments of the industries, infrastructure and amenities have affected the adjacent harbour (Naidu & Morrison 1994). Sediments and shellfish are contaminated with metals with the zone next to a battery factory having sediments metal concentration levels that were high enough to be considered a hazardous waste site. Results of study around the dump in Lami indicate the movement of metals away from the dump into the surrounding marine environment.

Economic – Industrial and economic development

The state of the environment in Suva is largely dictated by economic developments. In attempting to reduce their costs, industries have channelled their waste into pristine areas. In instances where the regulations are in place, lack of enforcement has resulted in the continued abuse of the environment. For example, the outfall from the Kinoya sewage treatment plant, although the pipe is 800 m long, the sewage is released at 300 m where the pipe is broken. This fault has been known for some time but no action has been taken due to the costs of fixing it.

Recent experiences have demonstrated that investments in a good environment make economic sense, as human activities are dependent on the functioning of the natural system.

The Suva harbour has two major industrial zones comprising shipyards, manufacturing plants, oil storage depots, food processing industries and other outlets that release effluents into the harbour. A battery factory near the harbour disposes its old batteries by tossing them over the fence into the surrounding intertidal sediments. The unsightly scene is obvious as plastic electrical cases were strewn over the area. The city dump is located on a reclaimed mangrove area. There are no linings so leachates flow directly into the harbour. Along the Coral Coast, a popular tourist destination with several large resorts, high levels of algal growth have been noted in recent years. The villagers are concerned about the impacts on the coral reefs and the fish stocks.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

In this analysis, two broad areas of policy are discussed, relating to the main concerns addressed in this report: (i) Freshwater shortage and (ii) Unsustainable exploitation of fish and other living resources, through integrated coastal area planning and resource management and conservation. These policy areas have been addressed at the regional and, to varying degrees, the national level throughout the Pacific Islands. The Pacific Islands Regional Ocean Forum (PIROF), held in Suva, Fiji in February 2004, resulted in draft Framework for Integrated Strategic Action, the elements of which are in agreement with the policy options proposed in this study. The difficulty, however, is finding ways and means of translating these well-conceived regional and national policies into action. Capacity building, awareness-raising, involvement of all stakeholders in planning and decision-making, paradigm shifts in governance and the law, and political will are all important if these policies are to be implemented. They cut across the GIWA concerns and issues addressed in this report.

The region has for almost 60 years adopted a regional approach to the similar concerns identified under GIWA. Policy issues within the Pacific Islands region are addressed by consensus, and major regional programmes are implemented by inter-governmental organisations or other bodies following a sometimes exhaustive consultative process. South and Veitayaki (1999) provided a detailed analysis of how these various regional approaches have led to workable arrangements in response to global initiatives. In the post-UNCED, Barbados and WSSD era the regional approach has continued and strengthened. In the early 1990s, in preparation for UNCED, most of the Pacific Island nations developed detailed National Environment Management Strategies (NEMS) for dealing with environmental issues, and these have laid the foundation for subsequent regional programmes and activities, such as the GEF-funded International Waters (IW) Programme currently being implemented by the South Pacific Regional Environment Programme (SPREP), as well as national programmes. The IW project was developed through an exhaustive national and regional consultation process which led to the Strategic Action Plan for the International Waters of the Pacific Small Island Developing States (SPREP 2001a).

On the surface, therefore, it would appear that the Pacific Island countries have the right mechanisms in place to develop policies needed to address GIWA concerns, either collectively, or at the national level. Unfortunately, however, this is not the case since there is great variation among them in terms of capacity. Whereas some governments have established Environment or Fisheries sections or have developed Sustainable Development Acts, many others have not. Most of the governments inherited colonial systems of government that remain largely intact, with Westminster-style, French or U.S. forms of government. This means that for many, hierarchical departments remain fiefdoms that compete for scarce resources, and integrated decision-making is the exception, not the rule. Scientific capacity is well below what is needed, school education systems often remain tied to those of far-off countries, and public awareness of issues is often uneven or lacking.

Freshwater shortage

Freshwater resources in the Pacific Islands are limited on the larger islands since, with the exception of a few nations (Papua New Guinea, Solomon Islands, Fiji) large river catchments are lacking. Great variations in flow rate are caused by catastrophic phenomena such as cyclones, and many watersheds are subject to high levels of run-off because of poor land use, clearing of native forest, mining and other activities. Water resources are finite on all atoll countries, and are subject to increasing depletion or contamination. Rainfall is highly variable by location, season and year, with many countries experiencing drought or floods. Many of the small atolls of Kiribati are uninhabitable because of a lack of potable water. Human habitation in the Pacific Islands has been governed by the availability of freshwater since the islands were first colonised around 3 500 years ago. Contamination of freshwater supplies by pollution from industry is common in urban areas, and standards in water use, treatment and protection of supplies are weakly applied. Rapidly increasing urban populations are placing unprecedented pressures on water supplies, as demonstrated by the city of Suva, where water cuts are frequent and distribution systems are old and inadequate. These problems have been widely recognised in the Pacific Islands, and have resulted in the development of a Regional Action Plan for use and conservation of freshwater.

While many Pacific Island countries have regulations for the use, treatment and conservation of catchments and water supplies, these are difficult to enforce because of traditional ownership of the land and resources, and inadequate consultation with traditional owners in the development of policies.

The United Nations has a long-standing regional commitment to water, and this responsibility now rests with the South Pacific Applied Geoscience Commission (SOPAC), through their Secretariat based in Suva, Fiji. SOPAC, like other IGOs in the Pacific Islands region, develops its annual workplan through a regional process of consultation, addressing concerns raised by their member countries through the development of national and regional projects which are carried out with support from donor countries and various agencies. There is also a Technical Advisory Group (TAG) to SOPAC which supports in-depth discussions on matters of regional and national importance.

The Pacific, perhaps more than any other region, has clearly articulated the challenges it has to address to achieve sustainable water management. The region has developed a strategic and holistic approach to overcoming these challenges, as articulated in the Pacific Regional Action Plan on Sustainable Water Management (SOPAC 2002). A number of Pacific Island countries are also preparing their National Plans of Action (NPAs) under the Global Program of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA), through the assistance of the South Pacific Regional Environment Programme. These NPAs will include important strategies on waste management.

The Pacific Islands region has also developed a regional partnership, known as the Pacific Type II Partnership on Sustainable Water Management, and an inter-regional Small Island Developing States partnership with the Caribbean, known as the Joint Caribbean Pacific Programme for Action on Water and Climate (JPfA) designed to implement this strategic approach.

Without additional resources, national and regional activities in this sector cannot continue. The priorities that have been identified through the national and regional consultations are contained in the Pacific Regional Action Plan for Sustainable Water Management, 20 actions of which form the JPfA, common to the Caribbean and Pacific.

Policy options

In July 2002, 18 Pacific Island countries formally endorsed the Pacific Regional Action Plan on Sustainable Water Management, 12 countries at Ministerial level. This Action Plan (SOPAC 2002) identified specific actions to address priority issues and constraints to achieving sustainable water management. The Pacific Wastewater Policy Statement and the Pacific Wastewater Framework for Action (Bower et al. 2002) are the two regional policy and action documents that provide a structure to regional and national interventions on wastewater management. Most of the policies are directly linked to the root causes identified in the causal chain analysis, and the Task team strongly endorse, and recommende that they will be implemented by Pacific Island countries.

Short-term options

Short-term actions recommended under the Framework for Action are:

- Identify water pollution sources and undertake preventative and corrective steps, including financial penalties for environmental and water degradation (Key Message 3: Action # 3: Point 6) (SOPAC 2002);

- Conduct environmental impact assessments as an integral part of planning for development projects to ensure environmental values and objectives are properly considered (Key Message 3: Action # 3: Point 7) (SOPAC 2002);
- Implement strategies to utilise appropriate methods and technologies for water supply and sanitation systems and approaches for rural and peri-urban communities in small islands (Key Message 2) (SOPAC 2002);
- Further pilot projects in different island environments to determine appropriate low-cost on-site sanitation technologies (e.g. compost toilets, gravel bed hydroponics or constructed wetlands) (Key Message 2: Action # 10: Point 1) (SOPAC 2002);
- Further applied research to establish guidelines for 'safe distances' (buffer zones) for existing sanitation options in different island environments (e.g. septic tanks, pit toilets) (Key Message 2: Action # 10: Point 2) (SOPAC 2002);
- Increase government, donor and community awareness of poor sanitation impacts on water resources and public health (Key Message 2: Action # 10: Point 3) (SOPAC 2002);
- Governments and regional organisations, the private sector and NGOs will actively cooperate to ensure that wastewater management policies and plans are integrated into the national development policies and plans and other cross-sectoral initiatives (Guiding Principle 1: Policy 1.7) (Bower et al. 2002);
- Governments, service providers and NGOs will ensure rural and urban communities will be given opportunities for active participation in the choice, development and implementation of wastewater and sanitation projects and on-going operation and maintenance of its facilities (Guiding Principle 4: Policy 4.4) (Bower et al. 2002);
- Service providers will take into account traditional knowledge and practices complemented by new approaches to wastewater management (Guiding Principle 4: Policy 4.6) (Bower et al. 2002).

Medium to longer-term options

Medium to longer-term strategies under the plan are:

- Develop catchment management plans for the rational allocation, use and protection of water resources. This may include the establishment of catchment management, protection and buffer zones (Key Message 3: Action # 3: Point 3) (SOPAC 2002);
- Apply best management practices to minimise impacts from activities such as logging, cultivation and mining (Key Message 3: Action # 3: Point 4) (SOPAC 2002);
- Implement strategies to improve the management of water resources, and surface and groundwater catchments (watersheds) for the benefit of all sectors including local communities, development interests and the environment (Key Message 3) (SOPAC 2002);
- Governments will develop national wastewater and sanitation policies and regulations that are consistent with international and national laws, regulations, technical standards, and obligations (Guiding Principle 1: Policy 1.2) (Bower et al. 2002);
- Governments will develop and implement appropriate wastewater and associated regulatory frameworks, compliance and enforcement requirements that benefit the specific cultures, customs, economies and environment of the people of the Pacific (Guiding Principle 1: Policy 1.3) (Bower et al. 2002);
- Governments will ensure that wastewater technologies and related infrastructure are appropriate to meet national and local priorities and needs, within the constraints of available finance and other resources, while recognising the need for protection of human health and the environment (Guiding Principle 2: Policy 2.2) (Bower et al. 2002);
- Planning of wastewater facilities will ensure acceptable access for all, with special regard to women, the disadvantaged, the disabled and those in rural and remote communities (Guiding Principle 4: Policy 4.5) (Bower et al. 2002);

Progress

In Fiji, the need to address important water and land-use policy issues has been recognised through the establishment of a variety of recent initiatives. For example, Fiji is currently developing an inter-sectoral National Land Use Policy and a National Code of Logging Practice has been developed to strengthen moves towards sustainable forest management. In addition, the Fiji Government has convened its first inter-sectoral, high-level National Water Committee and is addressing catchment management problems by establishing and allocating additional resources to a new section dedicated to solving land and water usage issues.

At the regional level, the GEF-funded and SPREP-implemented International Waters Project includes important strategies addressing freshwater. The implementation of the SOPAC Action Plan is being facilitated through the establishment of case study sites in a number of different countries in the Pacific Islands region. The establishment of these sites is critical for the sustainability of these initiatives once IW project has concluded. In addition, links between the IW project and the SOPAC Action Plan should be developed and strengthened wherever possible.

Barriers to implementation

Many of the actions proposed under the SOPAC (2002) plan will require difficult and sometimes socially unpopular decisions by governments. Using the example of Fiji, for policies to work, there is a need to identify the key stakeholders and to involve them in the processes, like for example, the land-owning units "mataqali", who own the land and whose activities such as logging, agricultural cultivation and

other land-based activities are of their own choice. As seen in the causal chain analysis for Rewa and Ba river catchments, the traditional landowners have every right to access their land and so policies will have to be made with their agreement. It is noteworthy that much of the market gardening that takes place in the Rewa catchment is carried out by Chinese, a disenfranchised group who would be completely marginalised if stringent land use policies were introduced.

The importance of traditional ownership of land and resources in Fiji has taken on increased prominence since the 2000 coup, and the "blueprint" developed by the Fiji Government has many elements that favour Fijian development over other ethnic groups. In a country where approximately half of the population is Indo-Fijian, the potential problems of this policy are obvious.

The private sector has to be conscious of potential medium-term changes that will result from policies that will work towards sustainable use of water supplies. Policies will need to be built into National Development Plans, and policies that favour the development of integrated water management strategies could have some negative impacts, and these would have to be anticipated and dealt with. For example, sustainable forestry or agriculture policies could create some reductions in employment opportunities in those sectors and so alternative employment or opportunities would need to be developed to counteract these losses. On the other hand, unless appropriate policies are put in place and implemented, the continued degradation of catchments and disruption of water supplies to rapidly growing populations will have long-term negative effects.

A common theme that was seen throughout the Pacific was the need for capacity building, and for awareness raising at all levels of society, on matters relating to proper wastewater treatment and sewage disposal practices.

Human factors such as population density, land use and sanitation methods have a large impact on the availability of water, the microbiological and chemical quality of water supplies and impacts on the freshwater resource. In addition, modern technologies are brought into these countries through many different programmes, but oftentimes these technologies are inappropriate for small islands due to the fact that many Pacific Island cultures still maintain much of their traditional lifestyles and value their traditions highly (e.g. the compost toilet still has not gained much popularity amongst the islanders). In some atoll countries, people traditionally use the beach as a toilet. When numbers are small, this is not a serious problem, but in areas with high population densities it becomes a serious pollution and health risk.

On most of the Pacific Islands, climate and water resource conditions vary considerably due to their locations, their topography, and their sizes and geology. Water supply for local communities is the most important water use, and approaches to provision of water supplies vary according to availability and sustainability of water resources. The implementation of the SOPAC (2002) plan will take much longer in some countries than in others. For example, in the causal chain analysis focused on the freshwater lens at Bonriki on the atoll of Tarawa in Kiribati, it was seen that governance and awareness were the main policy options and that there were water problems faced by the islanders due to the absence of water legislation and enforcement capacity to safeguard the use of the freshwater lens as their source of water. There is an urgent need for water resources legislation and policies put in place to monitor the use of water being pumped from the lens and the careful disposal of used water so that it does not enter the groundwater system again as recharge. At present, there are no policies in place to reduce water use, or to recycle water, and with increasing awareness of global changes occurring (these atolls being at the forefront of this plight), this has led to more funding being made available for training and preparedness initiatives. There is also a need for adequate water resource management and salinity monitoring of the water levels within the infiltration galleries so that no excessive pumping occurs.

Implementation

SOPAC has laid the foundation for countries to build upon in their future water management strategies. The steps required for their implementation at the national level will include:

- Consultation with all stakeholders and awareness raising on the importance of sustainable use of water supplies, and a detailed review of the SOPAC regional policy to see where it applies, and where it does not, in the national context. This consultation process should be facilitated by the national and local governments, in cooperation with the private sector.
- Development of appropriate legislation on water (where this does not exist) or modification of existing legislation in order to meet the requirements agreed to in the SOPAC Action Plan. These should provide for appropriate penalties where regulations are contravened. There will be a need for input from Environmental Legal officers in the drafting of legislation.
- Development of necessary strategies for enforcement, and sourcing of the necessary funds required for enforcement, and for upgrading of systems. NGOs as well as government could play a role in this process, and local communities should be involved.

Unsustainable exploitation of living resources

The call for integrated coastal area planning and management is a recurrent theme in global conventions and agreements to which the majority of Pacific nations are party, and in Action Plans and policy guidelines adopted by regional inter-governmental organisations and NGOs. Traditionally, the ethic of viewing the coastal area and adjacent waters as a whole is embedded in the traditions of all Pacific Island peoples; the concept of the vanua (Fiji) or fenua (Samoa) has governed traditional use of land and sea for thousands of years and does not separate one from the other. It would seem, then, that the translation of this important tradition into modern planning and management strategies would be a simple process, but this is not so. The hierarchical structure of governments, the sectoral approach even at the regional level (where inter-governmental bodies have specific sectoral mandates), and the largely top-down planning and decision-making process in governments, are all hindrances.

Furthermore, there is a serious lack of the capacity in most countries required to implement integrated planning and management of the coastal area, and a lack of political will to deal with difficult issues that might impede short-term gain in some sectors. Economics drive decisions in the resources and tourism sectors, for example, and issues such as environmental damage, or overexploitation, are sometimes swept aside or given low priority. It is instructive that, in most governments if not all, no position is identified as a Coastal Planner. One reason is that such a job would require a very broad background in many areas, and one rarely provided through existing tertiary educational systems, although this is now changing. The international community has itself had great difficulty in defining what exactly is required of a coastal planner (see Call to Action 1995).

Within the Pacific Islands region very few governments have developed national Integrated Coastal Management Plans. In the absence of such plans, mechanisms for cross-sectoral planning for the coastal area are poorly developed, and may involve many different government departments. As mentioned above, the elements for such planning have been proposed almost *ad infinitum* at the global and regional level. When asking why such plans have not been developed, it has been advised that this process is not attractive to donors (whose help would be needed). In the ocean and coastal sectors, responsibilities fall under many government departments in some Pacific Island countries – for example, 14 different departments are involved in Fiji.

It was agreed in the causal chain analysis that most of the problems relating to unsustainable exploitation of other living resources relate to lack of capacity to enforce regulations, the licensing system, inadequate fisheries data (especially for the subsistence fishery) and a lack of awareness among stakeholders and consumers of the consequences of overexploitation. For Fiji, it was agreed that overpopulation was not the main root cause, rather that the economy, government policies, lack of data and awareness were the most critical.

Recent community level studies have greatly enhanced awareness of the value of self-regulation of the inshore fishery: the International Ocean Institute, in partnership with government, the private sector, and NGOs ran a total of seven awareness-raising workshops throughout Fiji, attended by a more than 750 villagers. Many villages in Fiji are now requesting assistance on how to increase their capabilities in this area. Regulation is hampered, however, by the lack of data on most stocks fished in the subsistence sector, and hence lack of any regulation of the fishery. The Fiji's Locally Managed Marine Area (FLMMA) project referred to earlier (Tawake 2004), is an excellent example of the cooperation of local communities, government and NGOs in the establishment and monitoring of Marine Protected Areas (MPAs). There are 410 gazetted fishing areas (qoliqoli) in Fiji, and all of these could self-regulate given the necessary know-how and capacity. The Fisheries Division is unable to meet the demand for assistance because of shortage of staff, so this is being carried by the University of the South Pacific and NGOs, who are also stretched. Community regulated fisheries would enable resource owners to use appropriate social pressures for compliance, but at the moment there is no legal recognition of traditional "law", and this needs to be changed. Furthermore, government priorities in the fishery are driven much more by economics than by any conservation or sustainable ethics.

The fisheries licensing system needs to be reviewed and improved so that more sustainable and integrated management of stocks can be carried out. This would have to go hand-in-hand with the development of a much improved scientific basis for the fishery, focusing on stock estimates that would allow the implementation of realistic size and catch limits on subsistence fisheries. At the same time, there is a need for much greater feedback between government and the stakeholders. Illegal fishing such as the use of explosives, poisons and illegal nets is a significant problem in Fiji, and is poorly enforced because of the lack of human resources and funds in the Fisheries Division.

Aquaculture has serious implications in Fiji and elsewhere in the region. In Fiji, it is largely unregulated and there is no government legislation in place, although the government is bound by various agreements and conventions to which it is signatory, such as CITES. The industry is almost entirely involved with introduced species, such as Tilapia, two species of prawns, grass carp, pearl oysters, seaweeds (*Kappaphycus*) and, most recently, goatfish. Policies need to be put in place for the prevention of alien introductions. The seaweed *Kappaphycus* has now "escaped" from some of the many seaweed farms in Fiji, and is invading coral reefs in Vanua Levu and Viti Levu. The same species has become a serious nuisance in Hawaii, and is heading in that direction in Fiji. More attention should be paid to the potential of local species as candidates for aquaculture.

Problems faced by existing management regimes

Centrally-based management

In most Pacific Island countries government agencies responsible for managing coastal fisheries are also responsible for promoting their economic development. The latter cause is often given higher priority, even though it is recognised by most fishing agencies and coastal communities that the catch rates of fish and invertebrates from lagoons and inshore reefs have been declining for a number of years (King & Lambeth 2000). Changes in village lifestyle are bringing economic pressures on fishers to earn more income in order to satisfy higher material aspirations.

Most Pacific Island authorities have adopted the Western models of fisheries management, even though in temperate water countries such policies have repeatedly proved to be expensive and ineffective. These management regimes also require a sophisticated regulatory regime and extensive information on stocks, neither of which are possible given the limited resources and capacities of Pacific Island countries. The highly complex nature of tropical ecosystems places further constraints on implementation and enforcement of western-style fisheries management. There is a lack of understanding of these complex ecosystems, and the long-term impacts of management decisions made in ignorance of these ecosystems. Essentially, Pacific Islands fishery management regimes consist of a proliferation of regulations that government fisheries departments do not have the resources to enforce (Johannes 1994a, b).

Community-based management

Alternative management regimes for coastal fisheries have been proposed to recognise the traditional role of village communities in the allocation and management of fish stocks. A great deal has been written on this topic, and SPREP has addressed the issue in some detail. Many researchers have extolled the virtues of Customary Marine Tenure (CMT), but others doubt the social equity of CMT regimes, and whether they are effective for fisheries management (Anderson et al. 1999).

Important factors that affect the integrity of CMT, and also impact on governance issues at the national and local level can be identified as:

- **Demography change and urbanisation:** 35 % of Pacific Island people now live and work in towns, and this is expected to increase to 50 % by 2020. Fisheries close to urban centres face the greatest threats and require the most management. Urbanisation has led to a breakdown in community-based management.
- **Modernisation and economic development:** The introduction of new fishing technologies and the increasing incidence of destructive fishing practices have had a major impact on the depletion of coastal fish stocks in the Pacific Islands. Increasing demand for fish in urban centres has led to the exploitation of resources further and further away as traditional fishing stocks become depleted.
- **Equity considerations:** CMT systems are not necessary egalitarian in nature, and the control of some fishing stocks by a few chiefs has often resulted in inequitable distribution of resources. CMT systems may continue to prevent equitable treatment of participants in fisheries. Competition for cash has contributed to the erosion of traditional principles of reciprocity and redistribution in communities. CMT systems may also reinforce gender inequalities existing in traditional power structures. There is a growing need among communities for increased accountability and transparency in decision-making.
- **Transboundary concerns:** Within coastal systems it is questions whether traditional boundaries represent appropriate fisheries management units. CMT is usually represented by a patchwork of CMT areas along a given coastline, each with different sets of rules and access control. This makes the development of large-scale fisheries difficult.
- **Legal and policy issues:** A significant post-independence issue in most Pacific Island countries is not the fact that few give any formal statutory recognition of authority to CMT, nor are there any national policies that define the role of CMT in national fisheries administration. The possibility of codification of traditional law has been discussed by Fong (1994), although this has not yet happened. In Samoa, village by-laws have a legal status, and

allow village councils to manage marine protected areas with some authority (Fa'asili & King 1997). Efforts to provide a legal foundation for CMT systems and community-based management involve political issues far beyond the restricted field of fisheries legislation. Some fisheries administrators argue that CMT systems hamper the development of modern, efficient, national coastal fisheries. Others argue that the complexity of CMT systems may hamper the systematic and scientific planning and implementation of effective resource management regimes.

Towards co-management

SPREP suggests that in many areas CMT might eventually benefit by becoming embedded in the framework of co-management, essentially the mutual sharing of management responsibilities between local and national systems. There is a need to identify clear institutional roles for each partner that builds on their respective strengths.

According to Anderson et al. (1999) the respective roles of government and communities would be:

Government:

- Provide legislative framework;
- Identify sites under potential threat;
- Assist management to plan development;
- Provide technical assistance;
- Conflict resolution;
- Provide training and extension.

Communities:

- Identify management objectives;
- Implement the management plan;
- Develop mechanisms for effective communication.

Steps for establishment of co-management regimes

A number of recent examples demonstrate how co-management regimes can be established. One of the most publicised is the Village Fisheries Management Plan project developed in Samoa (Fa'asili & King 1997, King & Fa'asili 1999), and a more recent example from Fiji was the Locally Managed Marine Areas (LMMA) project, internationally recognised through the award of a Millennium Prize during WSSD in Johannesburg in 2002. King & Lambeth (2000) produced a manual for promoting the co-management of subsistence fisheries by Pacific Island communities.

The process adopted in Samoa (King & Fa'asili 1999) took two years to set up in an initial total of 44 villages, and was overseen by fisheries extension staff. As described by King and Fa'asili (1999) communities undertook to support and enforce government laws banning the use of chemicals and explosives. Traditional destructive fishing methods such as the use of plant-derived fish poisons (ava niukini) and smashing of corals to catch sheltering fish were also banned. Most villages made their own rules to enforce national laws regarding catch and size limits, and some villages introduced controls on the use of nets, torches and spear fishing. Other measures included killing crown-of-thorns starfish, banning the removal of beach sand and dumping of rubbish in lagoons. The majority of the villages (38) elected to establish their own small fish reserves, closed to all fishing. The strongly traditional set-up in Samoan villages greatly facilitated the success of the project, and involved consultation with the village Fono, the holding of various village group meetings (including women's groups) leading to the ultimate development of the Village Fisheries Management Plan and the establishment of a Fisheries Management Committee (King & Fa'asili 1999). An important step was the recognition of village by-laws used for the enforcement of regulations. This programme illustrates the steps required in the establishment of a successful co-management programme in the Pacific. The trigger for the programme in Samoa was substantial funding from AusAID. Aid funds were also critical in the establishment of the LMMA in Fiji. It will be important to see where these programmes will be sustainable once aid funds dry up.

Policy options

The following policy options need to be developed:

- Promotion of community-based marine resources management of the fisheries with cooperation between the resources owners, custodians, the government, NGOs and the fishing industry; the focus would be on sustainable development of marine resources and integrated coastal management;
- Changes to the current licensing system to improve feed-back between government and all the stakeholders and to encourage and promote sustainable fisheries using both scientific and customary practices;
- Development of appropriate research policies to enhance the gathering of data on inshore stocks, these to be used in the development of size and catch limits for the subsistence fishery;
- Formulation of better waste management strategies together with the implementation of acceptable environmental standards and practices;
- Identification and utilisation of better resource-use methods that are appropriate and cost effective;

- Development of legislation and regulations for the aquaculture and mariculture industries;
- Recognition and formulation of local by-laws that would allow greater monitoring and enforcement of fishery regulations at the community level.

Effectiveness of policy options

The effectiveness or otherwise of the promotion and adoption of community-based management regimes has been summarised above. More and more Pacific Island countries are moving towards adopting a co-management approach, and some innovative solutions have emerged. In Samoa, the Fisheries Act of 1988 was specifically designed to include provisions dealing with procedures whereby a village could declare its own fisheries rules as by-laws. There a strong link between communities and government that has evolved over the past 10 years (King & Fa'asili 1999). In Fiji, a linkage between communities and government has been assisted by a statute that prohibits government fisheries officers from issuing a fishing license to any person who has not already obtained the written permission of the representative of the customary fishing rights area concerned. The Native Lands and Fisheries Commission in Fiji has identified, surveyed and registered over 400 customary fishing rights areas (Waqairatu 1994).

Obstacles to policy options

The effectiveness of any fisheries policies introduced by Pacific Island governments is likely to be hampered by lack of funds, human capacity and knowledge. Co-management programmes will take a long time for communities to absorb and process the information provided by external partners such as government, a regional organisation or an NGO. Many months will be required to facilitate discussions at the community level before any plan can be developed and adopted.

Steps towards implementation

Governments need to develop a new paradigm in coastal fisheries, where some of the revenues are fed back to local communities to assist with co-management. In addition, alternative lifestyles, and extensive awareness-raising programmes need to be implemented, to accommodate for lost income under new management regimes, and to inculcate the necessary community will to actively pursue co-management strategies that will lead to more sustainable use of coastal resources. Political will of national governments will be a further requirement: unfortunately co-management results in fewer revenues for government, and sustainable practices if properly enforced would lead to a reduction in fish catch while stocks are allowed to recoup from many years of overfishing. Governments might, as a result, give only lip service to co-management. Lack of funds and trained human resources are also major barriers to effective implementation of new policy options. The root causes identified work against successful implementation of co-management. Given the enormity of what is involved, it would be a brave person who would try and indicate the costs of such policies. The benefits are clear (sustainable fisheries, recovery of fish stocks, involvement of all stakeholders in co-management, etc.) but the cost of achieving these could be substantial.

Conclusion

In conclusion, Pacific Island nations should be encouraged to:

1. Develop national Integrated Coastal Management Plans;
2. Establish inter-sectoral planning and decision-making bodies charged with the responsibility of implementing Integrated Coastal Management Plans. These bodies should include all stakeholders as well as government, the private sector and NGOs.
3. Promote the development of co-management of resources, and the established of marine protected areas.

Conclusions and recommendations

Conclusions

GIWA region 62 Pacific Islands is a vast oceanic expanse that is interspersed with many islands, which occupy only a small proportion of the area of the region. Transboundary effects on the oceanic scale are minimal, since the boundaries of the region are largely adjoining other large oceanic spaces. Any effects of the Australian continent to the west are nullified by the unpopulated Coral Sea, but to the northwest the region is influenced by land-based factors originating from Papua New Guinea, Irian Jaya, and the Philippine Sea. Transboundary effects are also minimal between the different island states, since they are largely separated by deep ocean. Within the countries, however, especially the larger archipelagic states, urban impacts, large watershed effects and other anthropogenic disturbances such as mining, forestry, agriculture and coastal development are considerable and often impinge on neighbouring islands or adjacent areas. Significant impacts are, however, generally localised and differ widely between high, low and atoll countries. It is thus impossible to generalise for the entire region.

On a region-wide scale several global impacts are becoming highly significant. These include climate change, sea level rise and sea surface temperature rise. Increasing frequency of the El Niño is resulting in severe changes to rainfall patterns and drought throughout the region. In addition, ENSO events, such as El Niño, also contribute to sea level changes and hence coastal erosion. The increase in sea surface temperature has been identified as of great importance, leading to increasing frequency and severity of coral bleaching. Many other ecological impacts are likely associated with this phenomenon, but remain poorly understood. There is also evidence to suggest that catastrophic climate events such as cyclones are increasing in frequency and severity. Sea level rise, if even at the most modest predictions over the next 50 years, will see the disappearance of many atolls, and increasing inundation and salination of coastal areas of high islands. These changes will lead to major population upheavals, migration and greater pressures on those countries that will need to accommodate these "eco-refugees". These global change patterns have an overarching impact on all the GIWA concerns and issues discussed in this assessment.

The most important concerns for the Pacific Islands region (not in order of importance) include freshwater shortage, habitat destruction and resource overutilisation. These are all having increasingly severe impacts on the quality of life of Pacific Islanders. The root causes behind these concerns include increasing population, market and economic trends and poorly coordinated government planning and regulation. Whereas significant progress in government and community reactions to these issues are evident, they are slow and fraught with many pitfalls. These are frequently because of a lack of proper management tools such as data, proper understanding of the issues, and capacity within government and the stakeholder communities to manage, regulate and enforce. These difficulties are exacerbated by burgeoning population growth in many of the countries, by a lack of funds, and by political expediency under pressure from developers, industry and communities. Essentially the region looks good on paper, with so many of the countries having signed and ratified post-UNCED Conventions and Agreements. In reality, few or none have the capacity to follow through with the enactment of laws and regulations required for compliance, or with the capacity (or political will) to enforce them.

Freshwater shortage is a serious problem now and in the future for most Pacific Island countries, and the problems differ between atolls and the high islands. Drought and water shortages are characteristic of atolls, and these are greatly magnified when large populations take up residence and tap in on a limited and highly vulnerable water source. In other countries, potable water may be readily available, but is poorly distributed, especially in rural areas. Significant changes in rainfall patterns will have long-term impacts on agriculture, forestry

and, indirectly, on the health of populations such as through increases in the occurrence of vector-borne diseases like malaria and dengue fever.

The vast majority of Pacific Island countries have a high proportion of subsistence fishers and farmers who depend on the living resources from lagoons, coral reefs and near-shore fishing grounds for their food security. Yet the reefs and lagoons are under increasing threat from rises in sea surface temperature (leading to coral bleaching), destruction of mangroves, tourism, urban development, extractive industries and other activities. The Pacific Island reefs are among the most extensive in the world, they are less threatened than, for example, those in regions such as the Sulu Celebes (Sulawesi) Seas, the South China Sea and the Indonesian Seas GIWA regions. On a local scale, however, there are many reefs that are certainly stressed. Dependence of some states on agriculture largely practiced on narrow coastal plains (or in the very marginal soils of atolls) means that changes in these ecosystems will result in a decreasing resilience and food security among subsistence communities.

The loss of traditional lifestyles, urban drift and the region-wide adoption of the cash economy are major socio-economic root causes. Another common theme throughout the region is the lack of capacity and expertise, and the lack of knowledge (awareness) to deal with issues that are impacting society. These shortcomings, in turn, lead to a lack of political will in governments. The governments are, in turn, largely vertically structured, which makes integrated planning and decision making very difficult. Furthermore, there is often inadequate consultation with stakeholder communities in all aspects of planning and development. But there are encouraging changes, in that island societies are becoming more pro-active and there is an increasingly mutual realisation that co-management of resources is crucial if there is to be any chance of sustainability in the future. At present, the indications are that sustainable development is a difficult, if not impossible goal, in the Pacific Islands.

Some of the answers to the future lie in regional initiatives and cooperation. The Pacific Islands region has, since the establishment of the South Pacific Commission in 1947, been a model of regional cooperation. The current inter-governmental regional organisations are the means whereby the Pacific Island countries can work together to address many of the problems identified in this assessment. Their collective performances at UNCED, Barbados and at the WSSD in Johannesburg are commendable. Some of the post-WSSD Type II initiatives proposed by the Pacific Islands certainly seek to address important issues of sustainability, and it is to be hoped that donors, partners and the Pacific Island countries will work together towards the important goals and milestones identified in these initiatives. On the high seas, the region has shown that agreement can be reached by most stakeholders on the management and conservation of highly migratory and transboundary fish stocks. Region-wide projects on coastal fisheries, oceanic fisheries, marine biodiversity and climate change continue to be pursued with vigour.

Over the next 20 years it is suggested that relatively few changes for worse or better are likely to occur in the region compared with the present-day situation. Increasing population, and global phenomena, however, may change the situation and cannot be accurately predicted here.

Recommendations

The recommendations are designed to address the root causes identified in the causal chain analysis. They are not listed in any particular order of priority. It is noteworthy that most of them are also reflected in the Pacific Islands Regional Ocean Forum (PIROF), held in Suva, Fiji on February 2-6, 2004.

1. All Pacific Island countries urgently need to develop and implement laws and regulations necessary for their compliance with global conventions and agreements to which they are signatory. Existing legislation should be properly enforced, and where new legislation is required, this will require substantial outside assistance, since many countries lack the necessary legal expertise.
2. Capacity building in all areas of ocean, coastal and watershed management is a priority for the region. This will require a concerted effort on the parts of national, regional and international education and training institutions, and significant funding. All future projects should be required to include a capacity-building component and should engage local communities.
3. The raising of public awareness on all coastal and ocean-related topics is badly needed, from the level of the village to that of government, planners and decision-makers. Schools, NGOs and the media should all play a part in this process. For the schools, this would require a significant investment in the development of national school curricula that reflect local needs.
4. Integrated planning and decision-making is a necessity for all governments. This requires a new paradigm in government, and involvement of all parties in the process, especially the stakeholders. For most countries, the development of an integrated coastal management plan should be a national priority. (This concept was strongly endorsed during PIROF: perhaps this endorsement will provide the impetus that has been lacking in the past).

5. There is a great need for research on and monitoring of the coastal and ocean environments of the region. The strengthening of research and monitoring capacity is an *a priore* need and, where necessary, regional and international cooperation and involvement of communities, NGOs and the private sector should be encouraged. The need should be expressed in all future bi-lateral and multi-lateral aid projects, and funding sought to support it. The strengthening of the research and monitoring capacity of national and regional universities should be encouraged, as well as cooperation with developed country institutions through partnership arrangements.
6. The regional and global lobbying of the Pacific Island countries is commendable, well organised and effective. This now needs to be brought down to the local community level, and proper feedback mechanisms between researchers, managers, government and communities need to be developed.
7. Environmental sustainability needs to be given greater emphasis by governments, many of which lack a relevant ministry or department for the environment. Implementation of sustainability policies will require political will, cooperation, and the provision of appropriate resources.
8. All Pacific Island countries developed National Environment Management Strategies (NEMS) as a lead-up to UNCED. Yet, many of the recommendations have yet to be implemented, and the NEMS are a decade out of date. The NEMS should be dusted off, revised if necessary, and translated into actions. The recommendations contained within NEMS could be linked to economic development plans, in the form of National Sustainable Development Plans.
9. Pacific Island countries must take greater ownership of projects managed by regional organisations, as it is the countries themselves who will have to implement sustainable practices. Countries must strive and seek support to bring this about, because if they fail to do so it could at their peril for the future.

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Annex I
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Ms. Aliti Susau	WWF-Fiji, Suva	Fiji	Environment
Ms. Batiri Thaman	Institute of Applied Science, University of South Pacific, Suva	Fiji	Environmental science
Ms. Jese Verebalavu	Marine Affairs Programme, University of South Pacific, Suva	Fiji	Socio-economics; Ecotourism
Ms. Leigh-Anne	Pacific Centre for Environmental and Sustainable Development, University of South Pacific, Suva	Fiji	Marine affairs
Ms. Tracy Berno	Tourism Studies Programme, School of Social and Economic Development (SSED), University of South Pacific, Suva	Fiji	Tourism
Mr. Owen White	South Pacific Applied Geoscience Commission (SOPAC), Suva	Fiji	Earth sciences
Prof. Bill Aalbersberg	Institute of Applied Science, University of South Pacific	Fiji	Marine chemistry; Marine conservation
Prof. Randolph Thaman	Geography Department, University of South Pacific, Suva	Fiji	Geography; Biogeography
Prof. Robin South	Coordinator, Marine Studies Programme & Director, IOI-Pacific Islands; Director, IOI (Australia), Townsville, Qld, Australia	Fiji/Australia/ Canada	Ocean policy; Systematics and ecology of benthic marine algae

Annex II
Detailed scoring tables

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	1	30	Freshwater shortage	1.7
2. Pollution of existing supplies	2	30		
3. Changes in the water table	2	40		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	40
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	30
Degree of severity	Minimum – Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	40
Weight average score for Other social and community impacts		**1.0**	

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	2	10	Pollution	2.2
5. Eutrophication	1	5		
6. Chemical	2	20		
7. Suspended solids	2	10		
8. Solid wastes	3	20		
9. Thermal	1	5		
10. Radionuclide	3	20		
11. Spills	1	10		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	40
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	30
Weight average score for Economic impacts		**1.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	30
Degree of severity	Minimum – Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	40
Weight average score for Other social and community impacts		**1.0**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	50	Habitat and community modification	2.5
13.Modification of ecosystems or ecotones, including community structure and/or species composition	3	50		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Other social and community impacts		**2.0**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	20	Unsustainable exploitation of fish	2.3
15. Excessive by-catch and discards	3	20		
16. Destructive fishing practices	2	20		
17. Decreased viability of stock through pollution and disease	1.5	20		
18. Impact on biological and genetic diversity	2	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	40
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Other social and community impacts		**2.0**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	10	Global change	2.6
20. Sea level change	3	40		
21. Increased UV-B radiation as a result of ozone depletion	1.5	10		
22. Changes in ocean CO_2 source/sink function	1.5	10		
23. Increase in sea surface temperature	3	30		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	30
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	40
Weight average score for Economic impacts		**3.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Other social and community impacts		**2.0**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Priority
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)		
Freshwater shortage	1.7	2.0	2.0	2.0	2.0	2.0	1.0	1.0	**1.7**	**5**
Pollution	2.2	2.0	1.0	2.0	2.0	2.0	1.0	1.0	**1.7**	**4**
Habitat and community modification	2.5	3.0	1.0	2.0	2.0	2.0	2.0	1.0	**1.9**	**3**
Unsustainable exploitation of fish and other living resources	2.3	3.0	2.0	2.0	2.0	2.0	2.0	2.0	**2.2**	**2**
Global change	2.7	3.0	3.0	3.0	2.0	3.0	2.0	3.0	**2.7**	**1**

Annex III
List of important water-related programmes and assessments in the region

The Strategic Action Programme (SAP) for the International Waters of the Pacific Small Island Developing States

The 5-year programme, which commenced in July 2000, is implemented by the United Nations Development Programme (UNDP), and executed by the South Pacific Regional Environment Programme (SPREP).

The Global Environment Facility (GEF) has agreed to provide up to 12 million USD to support the programme. In addition, SPREP, together with other partner agencies, the Secretariat for the Pacific Community (SPC) and the Forum Fisheries Agency (FFA), will contribute an additional 8 million USD.

Fourteen small island developing States are participating in the SAP. They are: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The oceanic component of the SAP, executed by SPC and FFA, will support the work of participating countries in developing management and conservation arrangements for their oceanic fisheries resources. It will be used to build the capacity of Pacific Island States to responsibly manage their tuna resources for sustainable economic benefit and to assist Island States fully participate in a new tuna management organisation that is currently being established for the western central Pacific region. The ocean fisheries management component will target the western central Pacific ecosystem whose boundaries correspond almost precisely with the commercial tuna fishery operating in that area.

The integrated coastal watershed component of the SAP will focus actions on freshwater supplies, including groundwater, marine protected areas, sustainable coastal fisheries, integrated coastal management planning, including tourism development and activities to promote waste reduction in local communities. Activities will concentrate on implementing 14 demonstration projects that demonstrate best practices and provide lessons for community-based management of threatened habitats and promote options for the sustainable use of natural resources. The Project Coordination Unit based at SPREP, in collaboration with the governments of the 14 participating States, will be responsible for the implementation of the demonstration projects.

For more information contact SPREP.

Small Island Water Information Network

The Small Island Water Information Network (SIWIN) aims to improve the quality of life and costs of water projects through an effective collaboration aiming to provide an up-to-date and timely information on the water sector for isolated small island states. This is a cooperative network of institutions and individuals that provide and exchange water related information relevant to small islands all over the world. The initiative was initiated by the Commonwealth Science Council, the British Geological Survey and the UK Department for International Development.

This network serves water professionals, institutions and the populations of small islands. Sources of information generally range from published or unpublished reports, textbooks, manuals, journals, case histories and accumulated experience. Due to the isolation of professionals and civil societies in Small Island Developing States (SIDS), SIWIN endeavours to provide as much detail as possible. SIWIN is a physical (institutions, professionals and society) and an electronic (website, e-mail) form of linking people and institutions across the globe.

For more information on this programme in the Pacific region contact:
SOPAC Secretariat
Private Mail Bag, GPO
Suva, Fiji Islands
Tel: +679 338 1377, Fax: +679 337 0040
director@sopac.org

SOPAC/EDF Island Systems Management

The goal of the Project is to address vulnerability reduction in the Pacific ACP States through the development of an integrated planning and management system, Island Systems Management initially focusing on eight Pacific States: Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. The objective is to strengthen integrated development in Pacific ACP States by concentrating on three key focal areas in the island system: hazard mitigation and risk assessment; aggregates for construction; and water resources supply and sanitation. The project will address problems such as: unavailability of accurate and timely data; weak human resource base; limited resources (money and infrastructure); and lack of appropriate management plans, policies and regulatory frameworks to deal with these three focal areas.

For more information on this programme in the Pacific region contact:
SOPAC Secretariat
Private Mail Bag, GPO
Suva, Fiji Islands
Tel: +679 338 1377, Fax: +679 337 0040
director@sopac.org

Pacific Regional Ocean Policy

The goal of the policy is to "ensure the future sustainable use of our Ocean and its resources by Pacific Islands communities and external partners". The goal emphasises the wise use of the Ocean and its resources. At present and in the future, the most pressing threat to Pacific Island countries will be from outsiders who ship oil and nuclear materials or fish in the Pacific Ocean. In addition, as marine resources in many parts of the world are fully utilised or are no longer available, Pacific Islanders and their partners will need to formulate effective policy and strategies for ensuring the future sustainability of their own resources.[1]

The guiding principles to the policy reflect the most important features of the Ocean and its use. These principles are purposely kept at a high level with general and encompassing statements that highlight the importance of the Ocean to Pacific Islanders and emphasise why it must be properly managed. It was determined early in the policy development process to elevate the Policy in this way to maximise the likelihood of reaching concurrence on its content. Moreover, there is now a period of reflection for the countries and people to consider the types of actions that can be pursued to deliver on the Policy's vision. These general statements therefore serve as the basis for all types of activities that are undertaken in the Ocean, coasts and islands in the future.

Principle 1- Improving our understanding of the Ocean

Understanding the Ocean is a huge call for humanity let alone the developing Pacific Island countries. However, Pacific Islanders need knowledge of the Ocean, how it functions and how its is affected by the changes caused by human activities. This knowledge will provide the basis for planning "sustainable uses of the Ocean and its resources, for the amelioration of pollution and harmful practices and for the prediction of weather, climate and ocean variability".

Effective resource management principles should be applied at all levels using all available methods. While the local communities should be involved in these management exercises, there also are specific roles for the district, national and regional stakeholders and institutions. The multiple uses of the Ocean require collaboration and partnerships between the users. Integration of traditional knowledge with contemporary scientific information is critical if the decision-makers of the region are to have a better understanding of ocean processes and ecosystems. This critical knowledge is "dependent on access to science and technology, to enable research, exploration and development of both living and non-living marine resources, and of long-term monitoring and observation".

To provide effective solutions, Pacific Island countries need to understand the threat of pollution from all sources and the best ways of addressing them. With increased human activities, pollution is likely to worsen. This poses threats to the long-term health of coastal systems and ecological processes, public health and the social and commercial use of Ocean resources.

Principle 2 – Sustainably developing and managing the use of Ocean resources

Pacific Island communities are heavily reliant on their marine resources and the services that the Ocean provides. The resources include the extractive uses of living and non-living resources as well as the non-extractive uses such as transport and communication, waste disposal, recreation, cultural activities and life support systems. Research and modern technology are expected to create new opportunities for developing Ocean resources and managing the impacts of natural and human activities in the Ocean. The future of Pacific Island communities is dependent on how the people maintain the health of the Ocean. It is therefore imperative that principles such as the precautionary approach, integrated development and adaptive management are articulated and implemented to ensure the sustainable use of the Ocean and its resources.

Pacific Island countries are responsible for the sustainable management of the world's largest tuna resources. These resources now supply an estimated one-third of all landed tuna, 40-60% of total supply to tuna canneries, and 30% of tuna to the valuable Japanese sashimi market.[2] Yet Pacific Islands countries are receiving less than 10% of the value of the tuna that is fished from their waters. In addition, Ocean resources management is based on to the maximum sustainable yield, which risks overexploitation if harvests are beyond this level (either due to poor enforcement of regulations or a lack of information on what the maximum sustainable yield is). Pacific Island countries need to explore new and suitable ways of getting a better return from the use of their tuna fisheries. For instance, it has been argued that the maximum economic yield (the harvest rate that maximises economic returns

[1] *The experience of another developing part of the world (the Caribbean) and its quest for sustainable oceans use is described in Miller, M. (2000)."Third world states and fluid sovereignty: development options and the politics of sustainable ocean management" Ocean and Coastal Management 42, 235-253.*
[2] *Gillet, R. M.McCoy, L.Rodwell and J.Tamate (2001). Tuna: A key economic resource in the Pacific, Asian Development Bank, Manila.*

from the fishery) is almost always less than the maximum sustainable yield (the most that can be harvested without reducing long-term stock size) and therefore should used in the management of the region's fisheries.[3] According to these experts, economic returns to the countries will increase and its sustainability better protected if the resources are managed according to their maximum economic yield.

Principle 3 - maintaining the health of the Ocean

The health and productivity of the Ocean is dependent upon the preservation of its ecosystem and the minimisation of the impact of human activities. The health and integrity of the marine ecosystem should be maintained so that it continues to provide the life support services it performs. In addition, the Ocean is the final repository of all the substances that enter the environment. In trying to maintain the health of the Ocean, Pacific Island countries need to have policies and strategies that address the threats from all their activities whether these are land-based, air-borne or in the high seas.

Ocean and coastal systems must be protected from degraded water quality caused by "accidental and deliberate dumping of fuels, chemicals and ballast water from ships, aircraft and satellite launches, and non sustainable resource use". Pacific Island countries must also guard against resource depletion that threatens the natural state of equilibrium in the world's Ocean.

Pacific Island countries must effectively control outsiders' activities in the region. This may require innovative policies and strategies that pass more responsibility for surveillance and control to their external partners.

Principle 4 – Promoting the peaceful use of the Ocean

Peaceful uses of the Ocean "means discouraging unacceptable, illicit or criminal activities' that contradict regional and international agreements". Pacific Island countries have to exercise control and enforcement over their maritime zones. They must also seek the support of other users such as the shipping nations, distant water fishing nations and naval powers. Again, it will not be possible to do this alone. International collaboration and partnership will be required. The uses of technology such as satellite monitoring system that is now used by the FFA will provide more effective options.

Educating the people to support the policies and strategies can be a useful tool. People will act properly if they know what is occurring and understand what they need to do. The peaceful use of the Ocean can be a polemic debate to settle but the strategies should spell out the appropriate course of action in a given situation.

Principle 5 – Creating partnerships and promoting cooperation

Pacific Island countries have demonstrated effective partnerships and cooperation in the sustainable management of the Ocean. This should be strengthened and extended to include new and emerging partners from outside the region. Partnership and cooperation are emphasised in UNCLOS and Agenda 21 but need to be specifically articulated in the Policies, Strategies and Action Plans of Pacific Island countries. Joint development and joint ventures are examples of partnerships that have been attempted in the past and can be the basis for future collaboration.

Pacific Island countries need to "maintain sovereign rights and responsibilities in managing, protecting and developing the Ocean". This is complex and requires innovative and creative ideas that should be transformed into policies and strategies. The countries must work with reputable international organisations to assist in capacity building and creating fundamental databases.

Strategic Actions

The policy lists the strategic actions that Pacific Island countries can undertake under each of the guiding principles. There is no sequence or order but the Strategic Actions present some of the activities that can be undertaken to achieve the policy's vision.

The strategic actions are directly related to the guiding principles and should provide guidelines for regional and national activities. Pacific Island countries can identify and prioritise their needs and then identify their appropriate action plans.

For more information contact
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JohnL@forumsec.org.fj

[3] *Petersen, E. (2002). Economic policy, institutions and fisheries development in the Pacific. Resource Management in Asia-Pacific Working Papers No.31:33.*

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Pacific Islands region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and

policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF".*

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference".*

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

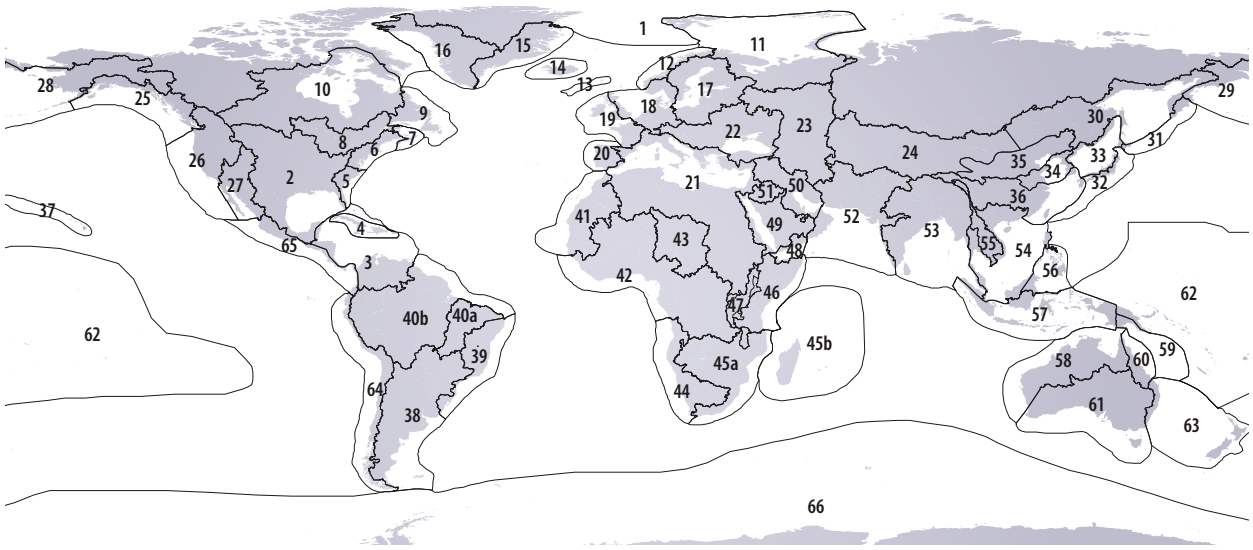
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1	*Arctic*	12	*Norwegian Sea (LME)*	24	*Aral Sea*	36	*East-China Sea (LME)*	46	*Somali Coastal Current (LME)*	58	*North Australian Shelf (LME)*
2	*Gulf of Mexico (LME)*	13	*Faroe plateau*	25	*Gulf of Alaska (LME)*	37	*Hawaiian Archipelago (LME)*	47	*East African Rift Valley Lakes*	59	*Coral Sea Basin*
3	*Caribbean Sea (LME)*	14	*Iceland Shelf (LME)*	26	*California Current (LME)*	38	*Patagonian Shelf (LME)*	48	*Gulf of Aden*	60	*Great Barrier Reef (LME)*
4	*Caribbean Islands*	15	*East Greenland Shelf (LME)*	27	*Gulf of California (LME)*	39	*Brazil Current (LME)*	49	*Red Sea (LME)*	61	*Great Australian Bight*
5	*Southeast Shelf (LME)*	16	*West Greenland Shelf (LME)*	28	*East Bering Sea (LME)*	40a	*Brazilian Northeast (LME)*	50	*The Gulf*	62	*Small Island States*
6	*Northeast Shelf (LME)*	17	*Baltic Sea (LME)*	29	*West Bering Sea (LME)*	40b	*Amazon*	51	*Jordan*	63	*Tasman Sea*
7	*Scotian Shelf (LME)*	18	*North Sea (LME)*	30	*Sea of Okhotsk (LME)*	41	*Canary Current (LME)*	52	*Arabian Sea (LME)*	64	*Humboldt Current (LME)*
8	*Gulf of St Lawrence*	19	*Celtic-Biscay Shelf (LME)*	31	*Oyashio Current (LME)*	42	*Guinea Current (LME)*	53	*Bay of Bengal S.E.*	65	*Eastern Equatorial Pacific*
9	*Newfoundland Shelf (LME)*	20	*Iberian Coastal (LME)*	32	*Kuroshio Current (LME)*	43	*Lake Chad*	54	*South China Sea (LME)*	66	*Antarctic (LME)*
10	*Baffin Bay, Labrador Sea, Canadian Archipelago*	21	*Mediterranean Sea (LME)*	33	*Sea of Japan/East Sea (LME)*	44	*Benguela Current (LME)*	55	*Mekong River*		
		22	*Black Sea (LME)*	34	*Yellow Sea (LME)*	45a	*Agulhas Current (LME)*	56	*Sulu-Celebes Sea (LME)*		
11	*Barents Sea (LME)*	23	*Caspian Sea*	35	*Bohai Sea*	45b	*Indian Ocean Islands*	57	*Indonesian Seas (LME)*		

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

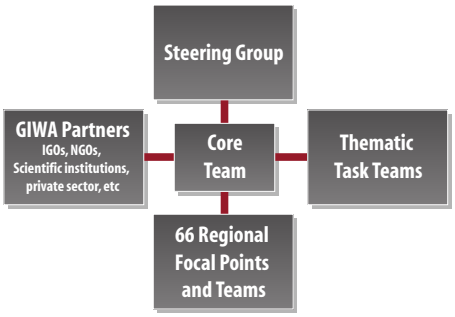


Figure 2 The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

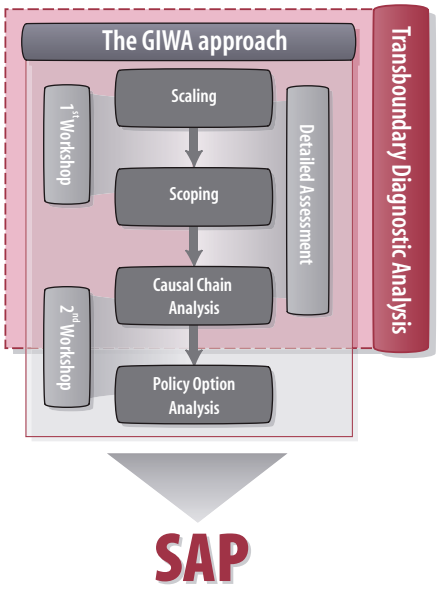

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the

results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern.
In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small — Very large 0 1 2 3	2	50
Degree of severity	Minimum — Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

Global International Waters Assessment

Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/ suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the GIWA assessment of the Pacific Islands region, which comprises more than 20 island nations or territories that exhibit enormous geomorphological, climatic, cultural and demographic diversity within a vast oceanic expanse. The region is unique because its inhabitants, who have close links with, and great cultural, economic and spiritual dependence on, their terrestrial and marine environment, are often the owners and users of these resources and ultimately govern their conservation and sustainable use. In addition to highlighting the overexploitation of fish and other living resources in densely populated areas, this report emphasises the vulnerability of many of these small island states to the impacts of climate change, particularly sea level rise and fluctuations in rainfall, which has enormous influence on the availability of freshwater in the region. The root causes of overexploitation and freshwater shortage are illustrated using several case studies and potential policy options to mitigate these problems in the future are discussed.

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