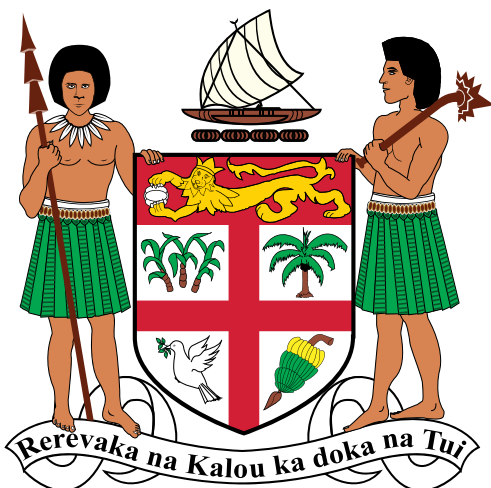




NATIONAL MARINE ECOSYSTEM SERVICE VALUATION

FIJI





MARINE ECOSYSTEM SERVICE VALUATION



The living resources of the Pacific Ocean are part of the region's rich natural capital. Marine and coastal ecosystems provide benefits for all people in and beyond the region. These benefits are called ecosystem services and include a broad range of values linking the environment with development and human well-being.

Yet, the natural capital of the ocean often remains invisible. Truly recognizing the value of such resources can help to highlight their importance and prevent their unnecessary loss. The MACBIO project provides technical support to the governments of Fiji, Kiribati, Solomon Islands, Tonga and Vanuatu in identifying and highlighting the values of marine and coastal resources and their ecosystem services. Once values are more visible, governments and stakeholders can plan and manage resources more sustainably, and maintain economic and social benefits of marine and coastal biodiversity in the medium and long term.

The MACBIO Project has undertaken economic assessments of Fiji's marine and coastal ecosystem services, and supports the integration of results into national policies and development planning. For a copy of all report and communication material please visit www.macbio.pacific.info.

MARINE ECOSYSTEM
SERVICE VALUATION

MARINE SPATIAL PLANNING

EFFECTIVE MANAGEMENT



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NATIONAL MARINE ECOSYSTEM SERVICE VALUATION

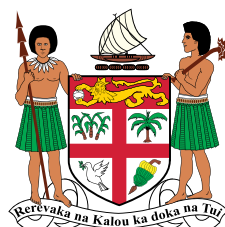
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Marine and Coastal Biodiversity Management
in Pacific Island Countries



On behalf of:



Federal Ministry
for the Environment, Nature Conservation,
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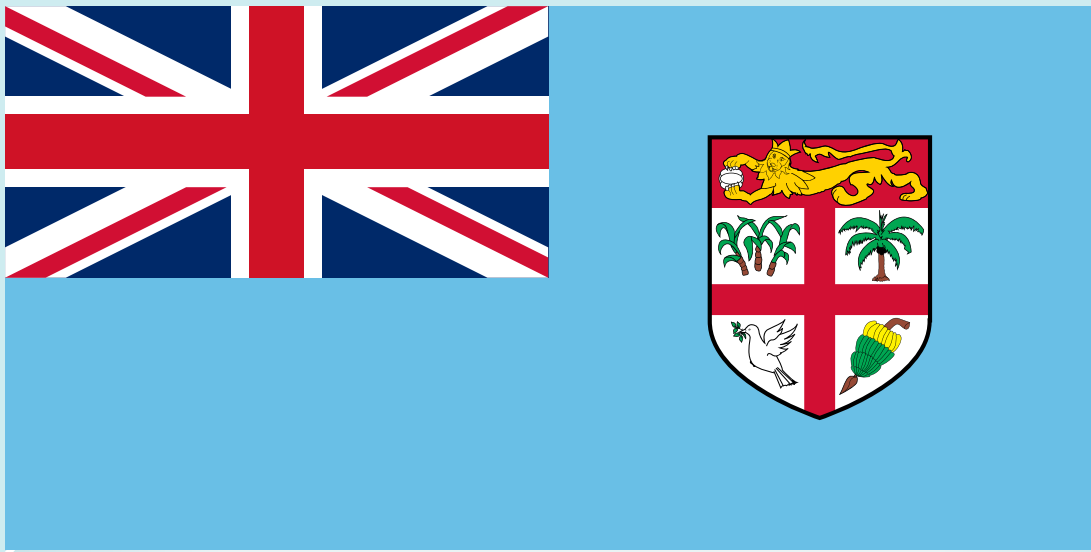
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Marine and Coastal Biodiversity Management
in Pacific Island Countries



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ACRONYMS

ADB	Asian Development Bank	MESCAL	Mangrove Ecosystems for Climate Change Adaptation and Livelihoods
AFD	French Development Agency	MMP	Marine Management Plan
BMUB	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	MPA	Marine Protected Areas
CBD	Convention on Biological Diversity	MSG	Melanesian Spearhead Group
CI	Conservation International	MSWG	Marine Sector Working Group
CPI	Consumer price index	NBSAP	National Biodiversity Strategic Action Plan
CRISP	Coral Reefs in the Pacific Initiative	NGO	Non-government Organizations
CSIRO	Commonwealth Scientific and Industrial Research Organisation	PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
DoE	Department of Environment	PIROP	Pacific Island Regional Ocean Policy
EEZ	Exclusive Economic Zone	PNG	Papua New Guinea
EIA	Environmental Impact Assessment	REDD	Reducing Emissions from Deforestation and Forest Degradation
FAO	Food and Agricultural Organisation	SCC	Social Cost of Carbon
FFA	Forum Fisheries Agency	SPC	Secretariat of the Pacific Community
FLMMA	Fiji Locally Managed Marine Area	SPREP	Secretariat of the Pacific Regional Environment Programme
FOFA	Fiji Offshore Fisheries Association	TAC	Total Allowable Catch
GDP	Gross Domestic Product	TEEB	The Economics of Ecosystems and Biodiversity
GEF	Global Environmental Facility	TLFC	The iTaukei Lands and Fisheries Commission
GIS	Geographical information system	TLTB	The iTaukei Land Trust Board
GIZ	German Agency for International Cooperation	UNCLOS	UN Convention on the Law of the Sea
HIES	Household Income and Expenditure Survey	UNDP	United Nations Development Program
IQMP	iQoliqoli Management Project	USP	University of the South Pacific
ISA	International Seabed Authority	WCS	Wildlife Conservation Society
IUCN	International Union for Conservation of Nature	WTP	Willingness-to-pay
LMMA	Locally Marine Managed Areas	WWF	Worldwide Fund for Nature
MACBIO	Marine and Coastal Biodiversity Management in Pacific Island Countries		



EXECUTIVE SUMMARY

Coastal and marine ecosystems provide a variety of *ecological functions*¹ that directly and indirectly translate to economic services with value to humans. For example, they support fish populations that constitute a significant source of protein and sustain ecosystem stability through conservation of biodiversity and mitigation of climate change through carbon sequestration. They act as sinks for by-products from industrial and agricultural production and provide recreational and aesthetic benefits. Marine and coastal resources influence cultural aspects of Fijian life and traditions. In particular, they are major suppliers of food for subsistence. Valuation studies of *ecosystem services* are increasingly called on to facilitate the incorporation of environmental values into the formulation of economic policy for more efficient (equitable and ecologically sustainable) marine and coastal management. We report on the *economic evaluation* of marine and coastal ecosystem services in Fiji. Specifically, seven marine and coastal ecosystem services categories were evaluated following The Economics of Ecosystems and Biodiversity (TEEB) approach. Ecosystem services analysed were subsistence food provision, commercial food harvesting, mineral and aggregate mining, tourism, coastal protection, carbon sequestration, and research and education.

This evaluation considers a particular local context, where marine resources in Fiji are used and managed by locally organised communities or villages (*mataqali*) that traditionally control very well delimited portions of marine areas as fishing grounds (*qoliqoli*), including coral reefs, seagrass beds and mangroves. From a total of 410 *qoliqolis* in Fiji, 70 are considered overexploited and 250 fully developed at maximum yield capacity; the remaining 90 *qoliqolis* are under a sustainable management regime. The sector is regulated by the Ministry of Fisheries and Forestry.

The national value of the seven environmental services was in the range of FJ\$ 2,281.81–2,487.41 (US\$ 1,142.60–1,172.23) million per year in dollars of December 2014.

Subsistence food provision from inshore fisheries and coastal resources was valued at FJ\$ 88.08 million (US\$ 44.09 million) and, a total national gross value of FJ\$ 59.04 million (US\$ 29.56 million) per year. Commercial fisheries occur inshore and offshore. Small-scale inshore commercial fisheries produce a value of FJ\$ 21.74–80.08 (US\$ 10.8–40.09) per hectare per year, and a total national value of FJ\$ 14.57–53.69 (US\$ 7.30–26.88) million per year. From 2003 to 2012, the annual volume and value of the *bêche-de-mer* production varied significantly from a low of 130 tonnes in 2009 to peak of 340 tonnes in 2005, giving an annual gross value of FJ\$ 5.5 million to FJ\$ 16.5 million respectively, thus demonstrating the boom-and-bust cycle within even short period of time. Commercial offshore fisheries are primarily based on tuna harvest and produce FJ\$ 0.16 (US\$ 0.08) per hectare per year or a total of FJ\$ 20.11 (US\$ 10.07) million per year.

In Fiji, the current price of river aggregate is nearly FJ\$ 5 per cubic metre and the annual production in 2014 was 300,000 m³, making a domestic industry with a value of approximately FJ\$ 1.5 (US\$ 0.76) million per year. To date we have not found reliable information on the value of mineral and aggregate mining except *revenue* from prospecting licenses paid by companies to the government, which total about FJ\$ 1.55 (US\$ 0.78) million per year.

Tourism accounted for FJ\$ 1,367.30 per hectare (US\$ 684.52/ha) for coral reefs and lagoons; FJ\$ 5,952.33 per hectare per year (US\$ 2,979.89/ha/yr) for mangroves and total gross value of FJ\$ 1,145.82 (US\$ 573.63) million per year.

Coastal protection was measured by exploring risk of damage to houses and hotels on the north and south sides of the two main islands of Fiji (Viti Levu and Vanua Levu). The annual value of avoided damage was estimated to be between FJ\$ 12.72 and FJ\$ 21.20 (US\$ 6.36–10.61) million per year. Note that this estimate excludes damage to a range of other assets; for example, public or private buildings that are not hotels, infrastructure and crops.

The social benefit of carbon sequestration plus avoided emissions by mangroves and the oceanic waters of Fiji's Exclusive Economic Zone (EEZ) was estimated to be worth about FJ\$ 147.67 million (US\$ 73.93 million) and FJ\$ 873.33 (US\$ 437.31) million, respectively. Unfortunately, there were no data on the extent of seagrasses or intertidal saltmarshes in Fiji. These ecosystems are also extremely important for carbon sequestration as the amount of carbon stored per hectare is among the highest in the world, comparable to that of mangroves.

We could not estimate a value for research and education due to lack of reliable information.

¹ Throughout the report, technical terms in italics are explained in the glossary (Appendix I: Glossary)

The value of marine and coastal ecosystem services in Fiji summarised in these values, will improve decision-makers understanding of the impacts of degradation of marine resources, on human benefits derived from fishing, tourism, coastal protection or carbon sequestration as consequence of pollution, damage and/or overuse. In turn, these data may contribute to decisions to support more sustainable and more equitable resource management.

TABLE 1 • Annual economic value of marine and coastal ecosystem services in Fiji (2014)

These values will help decision-makers better understand the impacts of degradation of marine resources on human benefits derived from fishing, tourism, coastal protection or carbon sequestration as consequence of pollution, damage and/or overuse. In turn, these data may contribute to decisions to support more sustainable and more equitable resource management.

Service	Ecosystem	Area	Unit value ^a		Total value	
			FJ\$/ha/yr	US\$/ha/yr	FJ\$m/yr	US\$m/yr
Subsistence fisheries	Inshore	6,704 km ²	88.07	44.09	59.04	29.56
Commercial fisheries	Small-scale inshore artisanal fishing	6,704 km ²	21.74–80.08	10.88–40.09	14.57–53.69	7.30–26.88
	Bêche-de-mer				5.5–16.5 (gross)	2.9–8.7 (gross)
	Offshore tuna	1.29m km ²	0.16	0.08	20.11	10.07
Mineral and aggregate mining	Total				3.05	1.54
	Deep-sea mining				1.55	0.78
	Aggregate mining	300,000m ²	5/m ²	2.5m ²	1.5	0.76
Tourism	Total				1,145.82 (gross)	573.63 (gross)
	Coral reefs and lagoon	6,704 km ²	1,367.3	684.52	916.66	458.90
	Mangroves	38,500 ha	5,952.33	2,979.89	229.16	114.73
	Coast	1,130 km	202,800.8/km	101,527.3/km	— ^c	— ^c
	Coastal land	1,130 km ²	2,028.00	1,015.27	— ^c	— ^c
	Fiji land	18,274 km ²	627.02	313.90	— ^c	— ^c
Coastal protection		2615 km ^{2d}			12.72–21.20	6.36–10.61
Carbon sequestration	Ocean ^e	1,290,000 km ²	6.77	3.39	873.33	437.31
	Seagrass	NA ^b	1,515.42	758.66	NA ^b	NA ^b
	Tidal marshes	NA ^b	2,759.94	1,381.70	NA ^b	NA ^b
	Mangroves	385 km ²	3,835.58	1,920.19	147.67	73.93
Research and education			NA ^b	NA ^b	NA ^b	NA ^b
Total					2,281.81–2,487.41	1,142.60–1,172.23

a Unless otherwise indicated;

b Not available;

c Total value for coasts is included in value for mangroves;

d Source: Fiji Lands Department;

e Only considers *social cost of carbon* (see Section 6.6.3).

1 INTRODUCTION

1.1 MARINE AND COASTAL BIODIVERSITY MANAGEMENT IN PACIFIC ISLAND COUNTRIES (MACBIO)

Funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) for a period of five years through the International Climate Initiative (IKI), the Marine and Coastal Biodiversity Management in Pacific Island Countries (MACBIO) project aims to strengthen the sustainable management of marine and coastal biodiversity by supporting economic ecosystem assessments, marine spatial planning and consultations in regard to marine protected areas (MPAs). The economic valuations of marine ecosystems, for example, this work, will contribute to national development plans. The project also aims to assist governments to extend and/or redesign MPA networks using seascape-level planning. The project will, in addition, demonstrate effective approaches for site management, including payment for ecosystem services and other conservation finance tools. Tried and tested concepts and instruments will be shared with governments and stakeholders throughout the Pacific community and disseminated internationally.

MACBIO is being implemented in five Pacific Island countries with the support of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in close collaboration with the Secretariat of the Pacific Regional Environment Programme (SPREP) and with technical support from the International Union for Conservation of Nature (IUCN).

These efforts to support improved management of marine and coastal biodiversity on the volcanic islands of Fiji, Solomon Islands and Vanuatu and the atolls of Kiribati and Tonga will help countries to meet their commitments under the Convention on Biological Diversity (CBD) Strategic Plan 2011–2020 and the relevant Aichi targets, including the Programme of Work on Protected Areas and the Programme of Work on Island Biodiversity.

All five countries are working towards achieving the quantitative Aichi Target 11: 10% of the coastal and marine environment in protected areas by 2020². As of 2014, the MACBIO countries had protected the following percentages of their marine and coastal environment: Fiji = 2%; Kiribati = 11%; Solomon Islands = > 5%; Tonga = 2%; Vanuatu = > 1%. With the exception of Kiribati, the countries remain a long way from achieving this Aichi target. Most of the existing MPAs are not ecologically representative and countries lack the means to ensure the conservation and sustainable use of resources. Most countries are facing severe challenges in regard to human resources and funding, inadequate law enforcement and lack of access to the information needed for marine biodiversity management.

Under the MACBIO project, IUCN Oceania is primarily responsible for conducting national economic assessments of marine and coastal ecosystem services in all five MACBIO countries, including conducting a data gap analysis. National reports on the value of marine and coastal ecosystem services will be provided to countries to inform marine spatial planning and marine resource management in general. This is one of those reports.

2 Aichi Target 11: By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

1.2 PROBLEM STATEMENT

Although the people and economies of the Pacific Island countries depend to a large extent on marine and coastal ecosystems, marine resource management should receive more attention in national plans and strategies (e.g. strategies relating to national development planning, tourism, food security, livelihoods, disaster mitigation and climate change adaptation) (MSWG 2005; PIFS 2007; Pratt and Govan 2011). This is due partly to a lack of understanding of the full *economic value* of marine and coastal ecosystem services (TEEB 2012).

The *economic contribution* of biodiversity and ecosystem services to the wellbeing of Pacific Islanders is understated for a variety of reasons including:

- Substantial resource-based *economic activity* exists outside of formal markets (subsistence)
- Customary resource tenure arrangements that poorly reflect individual economic decisions and pricing in markets
- Government agencies in the region typically have relatively low capacity in environmental economics and green national accounting
- Many countries of the region are relatively young and/or have lacked continuity in governance which has contributed to a lack of long-term data and analysis of ecosystem service stocks and flows at the national level
- Many countries of the region have a history of a two-tiered economy; one export and expatriate-led and the other traditional village-based and subsistence-oriented. Both tiers, however, are largely dependent on the same resource base. Planning and policy has generally struggled to address the interest of both dimensions of resource-based economic development at the national scale.

Identifying the *economic value* of marine and coastal ecosystems and taking these findings into account in national planning processes can help create incentives for more effective protection and sustainable use of marine species diversity. This, in turn, will help to sustain the benefits that people derive from those marine and coastal ecosystems.

1.3 PURPOSE AND OBJECTIVES

The MACBIO project has undertaken national economic assessments of marine and coastal ecosystems in the five project countries in a manner compatible with the global TEEB initiative. The work aims to contribute to national development plans and marine resource management policies and decision-making.

The principal objective of the economic component of MACBIO is to help countries to identify, quantify and, as far as possible, value in monetary units the most relevant marine and coastal ecosystem services in each MACBIO country. This should result in a national assessment of the human benefits of marine and coastal ecosystems. A comprehensive survey of the current state of knowledge and priority knowledge gaps is the first step towards accounting for marine natural capital and a *baseline* on which more detailed valuation studies could be built. The information provided within the reports can be used to guide, design and develop marine resources management plans, policies, assessments, legislation and tools, such as MPAs and environmental impact assessments.

This economic valuation is intended to enhance ecosystem-based marine and coastal resource management to lead to more resilient coastal and marine ecosystems, more effective conservation of marine biodiversity, and to contribute to climate change adaptation and mitigation, as well as to securing and strengthening local livelihoods and food security.

The aim of this study is to evaluate marine and coastal ecosystem services in Fiji. Ecosystem services explored here include: subsistence food provision, commercial food harvesting, mineral and aggregate mining, tourism, coastal protection, carbon sequestration, and research and education. The evaluation follows the TEEB approach (see Section 3.2).

1.4 DESCRIPTION OF THE GEO-POLITICAL BOUNDARIES OF ANALYSIS (SCOPE)

With an area of 180 million km² the Pacific represents around 50% of the global sea surface and a third of the Earth's surface. The 22 Pacific Island States and Territories comprise more than 200 mountainous volcanic islands and some 2,500 flat islands and atolls. The EEZs of the five project countries cover about 7,560,000 km², an area the size of Australia. The project region is one of the world's centres of marine biodiversity, with an unusually large number of endemic species. Despite the outstanding importance of this biodiversity for people's food and livelihoods, comprehensive species and habitat inventories are often lacking, as well as adequate valuation of the ecosystem services they provide to people.

MACBIO adopts a national-scale assessment of the economics of ecosystem services and biodiversity as a direct result of the factors that contribute to a lack of appropriate information to manage the natural wealth of Pacific Island nations.

In Fiji we chose to conduct a national assessment in part because it would have the largest and broadest potential relevance to policy and decision-makers. Furthermore, the human resources and funding required to conduct valuations specific to each policy or initiative related to the marine environment are unlikely to be available in small Pacific Island countries. An overview of the national values of marine and coastal ecosystem services can be used in a variety of ways, in a manner that policy-specific analyses cannot. Consider, for example:

- Although subsistence marine and coastal resource use and management primarily takes place at the village or community level, it does so within an economic and policy context at a national scale.
- Commercial fishing is often managed at the national scale (if not the regional (international) scale).
- Infrastructure investment decisions to mitigate disaster risk in coastal zones are often best managed through national planning processes in this region.
- Most Pacific Island nations have only one international airport, one main deepwater port and one primary commercial centre, so any economic development policy relying on these (e.g. to do with marine tourism) becomes an issue of national policy.
- Many Pacific Island nations have committed to national planning and policy efforts under one or more UN Conventions. National-scale capacity-building, data collection, storage and analysis help to reduce redundancy and perhaps create synergies with other parallel efforts and country-scale commitments in the region.
- Many of the compensatory and regulatory policy tools available and being used to promote behaviour in line with both natural wealth management and sustainable economic development objectives are most often national-level tools. These might include payment for ecosystem services approaches, entry and/or exit fees, hotel taxes, taboo seasons, catch limits, use of coral for construction materials, clearing of mangroves, water, sewage and solid waste disposal, among other issues and concerns.

1.5 REPORT INTRODUCTION

Coastal and marine ecosystems provide a variety of *ecological functions* that directly and indirectly translate to economic services and value to humans (Millennium Ecosystem Assessment 2005). They support fish populations that constitute a significant source of protein, sustain ecosystem stability through conservation of biodiversity and mitigation of climate change through carbon sequestration. Coastal and marine ecosystems also act as sinks for by-products from industrial and agricultural production and provide recreational and aesthetic benefits. Marine and coastal resources influence cultural aspects of Fijian life and traditions and are major suppliers of food for subsistence.

However, coastal and marine ecosystems have been historically depleted and degraded by human populations worldwide. The most pervasive human impact to coastal ecosystems is ecological extinction caused by overfishing (Jackson et al. 2001). According to Lotze et al. (2006), human impacts have depleted over 90% of coastal marine species, destroyed more than 65% of seagrass and wetland habitats, degraded water quality and accelerated species invasions worldwide. These transformations have accelerated over the last 150–300 years of civilization. Overexploitation and habitat destruction have been responsible for these major changes (Lotze et al. 2006).

The loss of biodiversity, overexploitation, degradation or pollution of marine and coastal resources occur due to market and institutional failures that are related to property rights regimes of resources and *externalities* associated with human activities. Open access resources such as fisheries may be depleted rapidly in the absence of formal or informal interventions that limit entry to fisheries or limit the amount of catch. If local fishing grounds or coastal areas are treated as common goods, they may be degraded and overexploited when there is a lack of self-governance or self-regulation at the local level. Weakness of property rights systems — for example, where there is a lack of enforcement or control — may create perverse incentives for overexploitation and even illegal extraction. In general, *de facto* open access to marine and coastal ecosystem goods and services creates incentives for their use, or even overuse, and not their sustainable use or conservation (Turner et al. 2000; Tietenberg and Lewis 2012).

Coastal and marine ecosystem goods and services that are traded in local markets or are destined for international markets often demonstrate public good characteristics in that their extraction creates *externalities* that are not included in exchange prices. This is a market failure. The market failure may be exacerbated by an institutional failure, i.e., the lack of regulation to limit the exploitation of such resources. Market failure may also be created by the absence of a market for such ecosystem services. That market and institutional failures create perverse incentives for overexploitation and resource degradation is well understood in environmental and resource economics (e.g. Tietenberg and Lewis 2012). The causes of resource degradation are usually summarised as having three components: the public nature of goods and services; *externalities*; and institutional (or policy) failures (Turner et al. 2000; Tietenberg and Lewis 2012).

Overuse, pollution, unsustainable practices and inadequate management decisions may affect the availability of marine and coastal natural resources that benefit people. For example, inshore reef fisheries are threatened by overfishing, destructive and illegal fishing and pollution (Jennings and Lock 1996). Agreements at international and regional levels call for an integrated approach to their management.

Information on the value of *externalities* and of environmental goods and services is relevant for implementing integrated management of marine and coastal resources by allowing more informed decision processes leading to more sustainable resource use. The value of marine ecosystem services may be influenced by the ecological function of the service, its impact on human *welfare* or simply by its level of scarcity. In economic analysis, this value is usually translated into monetary terms.

Valuation studies of ecosystem services are increasingly in demand to inform economic policy formulation and to create specific incentives for more efficient marine and coastal management that is also equitable and environmentally sustainable (Remoundou et al. 2009). A series of previous studies (e.g. Lal 1990; Sisto 1999; O’Garra 2007, 2012) have estimated and reported on the *economic value* of coastal and marine resources in Fiji. This information has provided a valuable contribution for policy design. For example, the values from Sisto (1999) were used to prepare the Fiji National Biodiversity Strategic Action Plan (NBSAP) (DoE 2007).

This report provides details of the country-specific context within which the economic evaluation was conducted and explains the methodological framework for the analysis. The specific methods applied in the report are discussed briefly; see Salcone et al. (2015) for the detailed methods. This report depends mainly on existing data and reports, synthesising this information and drawing conclusions where possible. In the process, important knowledge gaps and future data collection priorities are revealed. Results are provided for a range of marine economic goods and services (termed ‘services’). At the minimum, the human benefits from marine and coastal ecosystems are described in detail. This report identifies and describes Fiji’s marine ecosystem services, quantifies them if data are available and, where possible, calculates their *economic value*.

Fiji’s institutional and policy context are described in Sections 2.2 and 2.3, followed by an analysis of national policies, objectives, and initiatives that could use information about the human benefits of marine ecosystems. The TEEB initiative and global framework for *ecosystem service valuation* are presented in Chapter 3. Chapter 4 provides an overview of economic valuation literature relevant to Pacific Island States and Territories; technical methods are explained in Chapter 5.

The core of this report is Chapter 6 — the results of an economic assessment of marine and coastal ecosystem services. The first component of each subsection of the results, **Identify**, is a clear identification of how each natural marine and coastal ecosystem provides benefits to humans. That is, how *ecosystem functions* become ecosystem *services*. The second component, **Quantify**, is a review of data that quantitatively describe the magnitude of each ecosystem service. Early in the project it was established that a lack of comprehensive and reliable data would substantially limit the depth and breadth of economic valuation of ecosystem services. In response to this obstacle, an analysis of data gaps is a core focus of this national report. The third component, **Value**, presents the *economic value* of the ecosystem service as much as the data available allow.

This report indicates whether current resource uses are sustainable, that is whether the natural benefits can be expected to continue, to increase, or to decrease with current practices. The benefits of different *ecosystem functions* may accrue to few or many, nationals or foreigners, businesses or consumers. In order to understand the incentives that motivate different resource use patterns, it is important to consider who receives the benefits from the various marine and coastal ecosystems in Fiji. Chapter 6 describes the distribution and considers equity of existing ecosystem benefits.

The results for each ecosystem service are summarised and synthesised in Chapter 7. Recommendations and suggestions for how this information could be used are presented in Chapter 8. Since economic information is commonly plagued by misinterpretation, an explanation of the caveats and limitations of this research as well as disclaimers about how this information should not be used are presented in Chapter 9. Chapter 10 suggests areas for further research.



2 CONTEXT

2.1 DEMOGRAPHIC AND ECONOMIC COUNTRY PROFILE

The Fiji archipelago includes 320 islands and more than 500 islets and cays with a land area of 18,272 km², and a coastline of more than 1,130 km. The country is divided into four divisions, which are further divided into 14 provinces (Figure 1). Fiji has extended sovereignty of over 130,450 km² of archipelagic waters and 45,000 km² of territorial waters. Fiji has sovereign rights over the resources in its EEZ, an area beyond archipelagic baselines totalling 1.29 million km² (more than 60 times the land territory) (Fiji Fisheries Department 2012). It is estimated that around 6,704 km² are covered by fringing and barrier coral reefs, and mangroves cover an area of 385 km² (Watling 1985). According to World Bank indicators, threatened species in Fiji include six mammal species, 14 bird species, 13 fish species and 61 higher plants (World Bank 2012). Most marine and coastal resources are overexploited with major environmental challenges. Historically, mangroves have been cleared for human development for agricultural, grasslands or urban development, practices that have caused shoreline erosion over time (Nunn 2000).

According to the 2007 Census (Fiji Bureau of Statistics 2014a), Fiji had a population of 837,271 in 2007, of which 475,739 (56.8%) were iTaukei (indigenous Fijians), 313,798 (37.5%) were Indofijian and 47,734 (5.7%) were of other ethnicity. From the total population, 424,846 people (50.7%) live in urban areas; in urban areas 211,504 people (49.8%) are iTaukei and 177,880 people (41.9%) are Indofijian. Over 50% of the population is coastal (SPREP 2012).

An estimated 31% of the population lives in poverty; 43% of rural people and 19% of the urban population live in poverty. The proportion of economically dependent population to productive age population is 50.8%. The economically dependent population is a combination of the elderly (aged over 65 years) and the young (aged under 15 years). The productive age population is the population of 'working age' (between 15 and 65) (Fiji Bureau of Statistics 2014a).

The country has experienced an average growth of 3.0% in its gross domestic product (GDP) in recent years: 3.0% in 2010, 2.7% in 2011, 1.8% in 2012 and 4.6% in 2013. The GDP was FJ\$ 6,188.4 million (US\$ 3,098.07m) in 2013³. The GDP per capita was FJ\$ 7,179.1 (US\$ 3,594.04). Of the total GDP, FJ\$ 128.7 million (US\$ 64.43m) (2.08%) was derived from fishing and aquaculture. This value can be further divided into subsistence fishing — FJ\$ 39.7 million (US\$ 19.88m), informal inshore commercial fishing — FJ\$ 6.8 million (US\$ 3.4m), general government⁴ — FJ\$ 1.3 million (US\$ 0.65m), and non-general government (private activity) — FJ\$ 81 million (US\$ 40.55m) (Fiji Bureau of Statistics 2014a).

Exports from the marine resources sector were FJ\$ 86.9 million (US\$ 43.5m) GDP in 2013, of which FJ\$ 20.6 million (US\$ 10.3m) was from canned fish and from FJ\$ 44.4 million (US\$ 22.23m) from fresh finfish (Fiji Bureau of Statistics 2014a).



In Fiji 6,704 km² are covered by fringing and barrier coral reefs.

3 In this report, all prices are in Fiji dollars (FJ\$) and exchange rates are calculated based on values of December 2014 by using the consumer price index (CPI), as reported by the Asian Development Bank (1999, 2005, 2014), Fiji Bureau of Statistics (2014a), and the latest information updated from the web page of the Fiji Bureau of Statistics (Fiji Bureau of Statistics 2014b). For the exchange rate we used the information from Reserve Bank (Reserve Bank of Fiji 2014). The exchange rate for the end of December 2014 was considered as US\$ 1 = FJ\$ 1.9975.

4 General government includes central government wages and salaries, local government and non-profit statutory bodies. Non-general government includes the private sector and for-profit government-owned entities.

2.2 INSTITUTIONAL CONTEXT

There are three regional organisations that play a major role in use and management of marine and coastal resources, the Secretariat of the Pacific Community (SPC), the Pacific Islands Forum Fisheries Agency (FFA) and the Secretariat of the Pacific Regional Environment Program (SPREP). (Gillett 2011). The SPC has an active role in assisting member countries with marine and coastal fisheries development and management and also in developing scientific research and data collection on the state of marine resources. The FFA is more oriented to assisting member countries in management of tuna resources, including surveillance, economic and legal aspects. SPREP has been charged by the governments and administrations of the Pacific region to help with the protection and sustainable development of the region's environment. Other regional organisations, such as the University of the South Pacific (USP), have different levels of involvement in marine and coastal resources.

At the national level, the Department of Fisheries of the Ministry of Fisheries and Forests is the main institution involved in decision-making regarding marine and coastal resources in Fiji. Fiji's Department of Fisheries is responsible for the formulation and implementation of policies in the fisheries sector (Gillett et al. 2014; Sloan and Chand 2015). However the Department of Fisheries places greater emphasis on development of fisheries than their sustainable management and there has also recently been a decline in capacity in the coastal fisheries management programme, in particular (Gillett et al. 2014).

Other government departments are also involved in institutional and legal aspects of coastal and marine resource management. For example, the Department of the Environment (DoE) of the Ministry of Local Government, Housing and Environment is the chair for the Fiji NBSAP and Integrated Coastal Zone Management and Protected Area Committees. Other departments, including the Department of Tourism of the Ministry for Industry and Trade and Tourism, and the Land Use Unit of the Ministry for Lands and Mineral Resources also have important roles in marine and coastal resource management in Fiji.

The modern legal system clearly recognises some rights of iTaukei ownership, access to and use of certain natural resources. This includes, for example, ownership of 88% of Fiji's land, and access to and use of (but not ultimate jurisdiction or ownership over) nearshore fisheries resources within limits as prescribed by law (Sloan and Chand 2015). Property rights and native lands of Fiji are administered and controlled by two government agencies and a private independent entity. The government Land Use Unit is a newly established unit to manage the Government Land Reform Program in accordance with the Land Use Decree 2010. The iTaukei Lands and Fisheries Commission (TLFC) of the Ministry of iTaukei Affairs plays a crucial role as the custodian for iTaukei property rights (Sloan and Chand 2015). The TLFC was established in 1880 to register native lands, ownership of such lands and to classify customary roles and migration records of communal units (iTaukei Lands and Fisheries Commission 2013). The TLFC's role is primarily as custodian of the various registrations and compliance with regulations covered by the *iTaukei Lands Act* CAP 133 and the *Fisheries Act* CAP 158 Section 14–20. Its role includes ascertaining what lands and fishing rights areas are the rightful and hereditary property of iTaukei owners, registering the ownership of iTaukei lands and customary fishing rights, adjudicating in disputes on the rightful ownership of iTaukei lands and customary fishing rights, adjudicating in disputes relating to customary headships or title, and providing information relating to the TLFC's roles (see www.itaukeiaffairs.gov.fj/index.php/sections/itaukei-lands-fisheries-commission).

In 1989, the Fiji Government decided that the TLFC should also look at the proper demarcation of boundaries and set up a unit to survey the boundaries and register ownership of customary fishing rights, demarcate and set aside sites as village reserves and survey the un-surveyed iTaukei Land (iTaukei Lands and Fisheries Commission 2013).

The iTaukei Land Trust Board (TLTB) is a government-dependent entity that is responsible for administering all iTaukei lands. The chairman of the board is the Minister of iTaukei Affairs. The TLTB becomes in practice the 'landlord' of iTaukei lands (83% of land held by Fijians) which acts on behalf of iTaukei landowners to approve new leases and renewal of leases, collect and distribute land rent, improve the pattern of land subdivision and help improve landlord and tenant relations (iTaukei Land Trust Board 2014).

Coastal marine resources in Fiji are used and managed by locally organised communities or villages (*mataqali*) that traditionally control very well delimited portions of marine areas as customary fishing grounds (*qoliqoli*⁵), including coral reefs, seagrass beds and mangroves (Golden et al. 2014). The *iQoliqolis* are distributed across the country as shown in Figure 2. The fishing rights of each *qoliqoli* are held by the various respective *yabusa* (tribes). From a total of 410 *qoliqolis* in Fiji, 70 are considered overexploited and 250 are fully developed at maximum yield capacity. The remaining 90 *qoliqolis* are considered as used under a sustainable regime (Singh 2005).

5 *iQoliqoli* is the customary fishing right assigned to indigenous people who belong to the same clan group. *Qoliqoli* refers to the physical area over which the rights extend.

There is no fishing quota control for inshore fisheries in Fiji, and the control of overharvesting in inshore fisheries relies on communities engaging in some degree of fisheries management and/or conservation. In a report on the state of conservation sector of Fiji, the Austral Foundation was pessimistic about the effectiveness of conservation initiatives in Fiji (Austral Foundation 2007). The foundation reported four government agencies interested in conservation, 23 non-government organisations (NGOs), at least a dozen community-based groups working on conservation, and about 150 professionals employed for such purposes. The report claimed that most projects fail to continue beyond the pilot phase and that communities saw ephemeral projects failing on long-term capacity-building.

Overexploitation of fishery resources in Fiji is an issue that has not been clearly addressed and that has no easy solution. Several initiatives have been implemented in inshore fisheries aiming to delimit marine areas with some degree of access control. For example, Fiji's locally managed marine areas (LMMAs) and MPAs assign local communities a key role in their successful implementation. Locally managed conservation has the advantage that traditional ecological knowledge is easily incorporated into management which encourages equitable exchange of knowledge and fosters shared responsibilities with local villagers as long as decision-makers recognise traditional ecological knowledge (Drew 2005; Cinner and Aswani 2007). The implementation of LMMAs is recognised as one of the more innovative initiatives for conservation of marine resources in Fiji. The LMMAs were born in 2000 after a Roundtable on South Pacific Nature held in Fiji. A LMMA corresponds to "an area of near shore waters and coastal resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organisations, and/or collaborative government representatives who reside or are based in the immediate area" (Hastings et al. 2012). The LMMAs are established inside different *qoliqolis*. Today there are more than 10,000 km² of LMMAs and more than 200 LMMAs already established (Mills et al. 2011a).

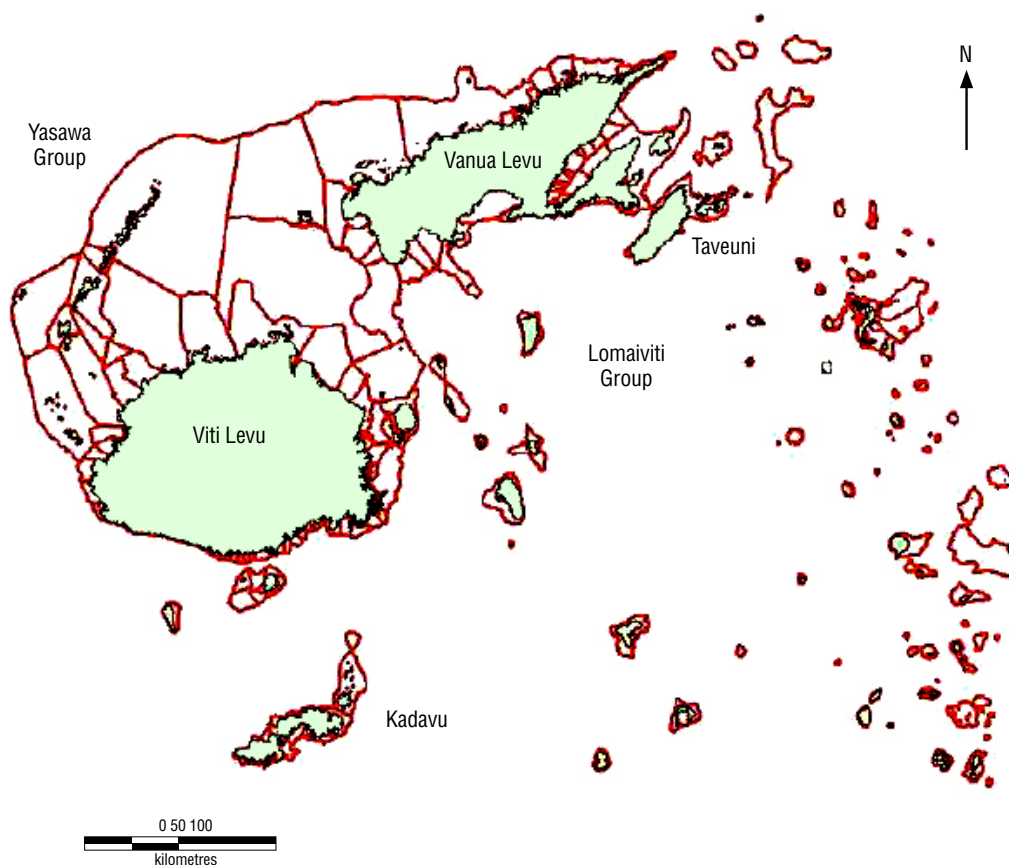


FIGURE 2 • Customary fishing grounds (iQoliqoli) in Fiji

Source: Korovolavula et al. 2007

Marine protected areas are defined by the IUCN as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008; Day et al. 2012). By this definition, areas primarily established for exploitation and extraction, such as fisheries, that have no defined long-term conservation, restoration or ocean recovery goals cannot be considered MPAs (IUCN 2012).

The IUCN divides MPAs into six management categories, depending on their objectives: 1a) strict nature reserve; 1b) wilderness area; 2) national park; 3) natural monument or feature; 4) habitat/species management area; 5) protected landscape/seascape; 6) protected areas with sustainable use of natural resources (Dudley 2008; Day et al. 2012). The category is defined by the primary management objective (that covers over 75% of the area). These management categories can be applied under different governance types: governance by the government (which also may include government-delegated management, e.g., to an NGO); shared governance (collaborative among many national and or international entities); private governance or governance by indigenous people and local communities (Dudley 2008; Day et al. 2012).

MPAs in Fiji are established as part of LMMAs and are regulated by the Fisheries Act. Although LMMAs have been a successful initiative, they have also revealed some legal challenges (Techera and Troniak 2009). For example, MPAs may be better enforced under the Fisheries Act in cases with conflicts with adjacent villages or outsiders; however, LMMAs are successful because they are product of local conservation and management initiatives that also incorporate customary law and local environmental knowledge (Cinner and Aswani 2007; Golden et al. 2014).

Major constraints to the success of resource management through protected areas of various types have been identified. For example, Lane (2008) remarked on lack of integration and coordination, the need for system-wide governance reform, a high degree of centralisation as an impediment for local decisions, and lack of coastal planning and information. All these factors reveal limitations or considerations of the capacity for successful local governance for coastal management in isolation of other governance structures or decision-making forums.

2.3 POLICY CONTEXT

Fiji signed the CBD at the Rio Summit in 1992 and received a grant from the Global Environmental Facility (GEF) to finance the elaboration of a NBSAP. The grant allocation was facilitated by the United Nations Development Program (UNDP) and the NBSAP was finalised in 1999. The responsibility of preparing the NBSAP was delegated to the DoE, which was guided by a steering committee that included representatives of a broad range of government departments, NGOs, academics and UNDP (DoE 2007). The NBSAP has been steering conservation policies and initiatives in Fiji since it was first released in 1999, and is the main policy addressing marine and coastal resources in Fiji. The implementation framework 2010–2014 for the NBSAP was published in 2010 (DoE 2010). The NBSAP adds to existing strategies, policies and plans like the Fiji State of the Environment of 1992, National Environment Strategy of 1993, the Sustainable Development Bill of 1997 and its revised version of 1999 (DoE 2007). These have been used to propose and design policies related to sustainable resource management and conservation and environmental protection policies, and also to improve and establish institutional design like defining powers, duties and functions of relevant government departments.

In addition to the CBD, Fiji has signed a series of other agreements and conventions (Techera and Troniak 2009) including: the Ramsar Convention of 1971 for wetland conservation which Fiji signed in 2005; the World Heritage Convention of 1972; the UN Convention on the Law of the Sea (UNCLOS) of 1982, which established the broad legal framework for protection and governance of the oceans; Agenda 21 that resulted from Rio Declaration of 1992 at the UN Conference on Environment and Development that includes the requirement for protection of living marine resources and use limitations by designing protected areas and by other means; the Barbados Declaration on Sustainable Development and the Action Program of 1994 focused on sustainable development of small island countries; and the World Summit on Sustainable Development of 2002 which sought to establish networks of MPAs by 2012.

Perhaps one of the more promising actions of the Fiji Government is the commitment taken at the Barbados Plan of Action in Mauritius in 2005, and reiterated at the Small Island Developing States meeting in Apia in 2014, where the government declared the intention to effectively manage and finance at least 30% of Fiji's marine areas by 2020 (Jupiter et al. 2010; Wise 2014). A series of additional actions should be taken to achieve this commitment, given that most of the conservation initiatives to date have depended on efforts by partners of the Fiji Locally Managed Marine Area (FLMMA) network, and not necessarily on government actions. For example, an analysis of the opportunistic expansion of FLMMA to date showed that Fiji will require an additional 10–30% effective coverage across all marine and coastal resources to achieve the promised 30% goal (Jupiter et al. 2010; Mills et al. 2011b).

Sloan and Chand (2015) described the legislation and policies relevant to the management of Fiji's nearshore fisheries resources in detail; many of these are relevant to management of Fiji's marine resources more broadly. For example they identify the Constitution 2013, the *Fisheries Act 2006* (which is relevant to *qoliqoli* areas, MPAs, protected species

and permits and licences), the Offshore Fisheries Management Decree 2007 (which deals with Fisheries Management Plans, MPAs, licensing, monitoring and control), the *Marine Spaces Act*, draft Aquaculture Decree, draft Inshore Fisheries Management Decree, International Seabed Mineral Management Decree, *National Trust for Fiji Act*, *Continental Shelf Act*, *Endangered and Protected Species Act*, Regulation of Surfing Areas Decree, *State Lands Act*, *iTaukei Affairs Act* and the *Environmental Management Act* (Sloan and Chand 2015). Policies guiding management of Fiji's nearshore fisheries include the People's Charter for Change, Peace and Progress, NBSAP, Roadmap for Democracy and Sustainable Socio-Economic Development, Green Growth Framework, Government Ministry Strategic Plans, Government Ministry Annual Corporate Plans and the Integrated Coastal Management Framework (Sloan and Chand 2015). Some of these are discussed in more detail below.

Techera and Troniak (2009) describe a series of local and regional laws and policies supporting MPAs, such as the Apia Convention of 1976 on the Conservation of Nature in the South Pacific and the SPREP or Noumea Convention of 1986 on the Protection of Natural Resources and the Environment of the South Pacific Region which entered into force in 1990. The Noumea Convention requires state parties to prevent and regulate pollution, and to ensure proper environmental management and development of natural resources.

In 2002, the SPC proposed a community-based fisheries management programme for Fiji (Fa'asili et al. 2002). The programme considered an integrated approach built on participative learning activities that are employed in Fiji by NGOs in dealing with communities. The proposal was named the *iQoliqoli Management Project* (IQMP) to emphasise the intention to place management responsibility for *iQoliqoli* with the owners of customary fishing rights. The main aim of the *iQoliqoli* management strategy was to establish a community-developed fisheries management plan for each village participating in the IQMP. The process recommended for the proposed IQMP by SPC is summarised in Figure 3.

The IQMP has not yet been implemented. However, the spirit of the proposed IQMP is being followed in practice, given that the current process to establish a LMMA starts with an expression of interest from a community to a partner organisation involved in the FLMMA, e.g. Worldwide Fund for Nature (WWF) (Techera and Troniak 2009). The partner organisation facilitates capacity-building in the community on management and action planning, biological and socioeconomic monitoring. The community, with support from the partner organisation, prepares a Marine Management Plan (MMP) for their *iQoliqoli*. Once the MMP is designed, the implementation, monitoring and enforcement is the responsibility of the local community. Furthermore, customary traditional ecological knowledge can be incorporated in the management plan (Drew 2005; Cinner and Aswani 2007).



Marine and coastal resources influence cultural aspects of Fijian life and traditions.

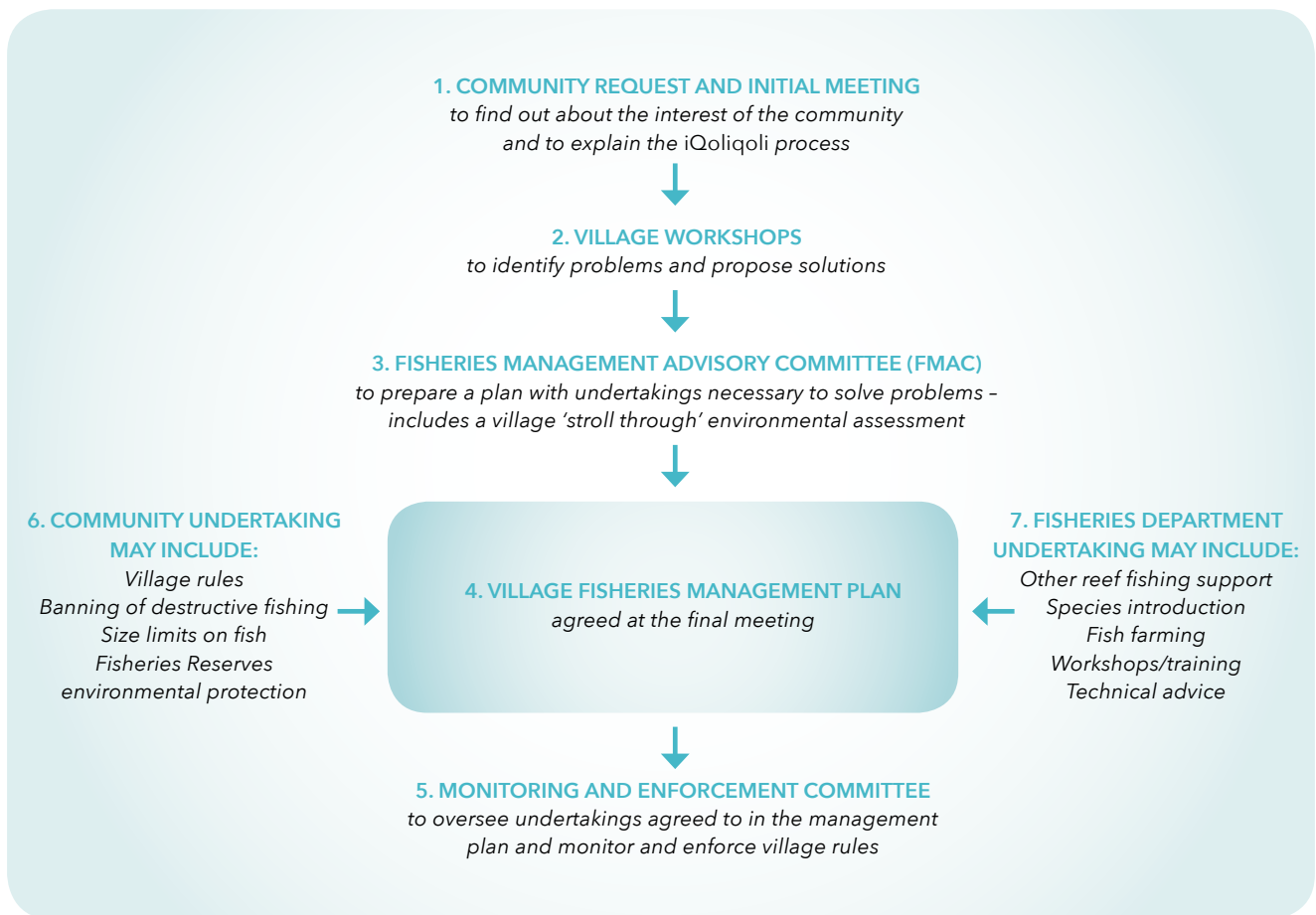


FIGURE 3 • The iQoliqoli process recommended by SPC for Fiji's IQMP

Source: Fa'asili et al. 2002

The main legal body that regulates marine resources in Fiji is the Fisheries Act. The Fisheries Act allows the Fisheries Department and the Ministry of Fisheries and Forests to regulate the use of marine resources, which include conservation measures such as the creation of MPAs and other management decisions (Techera and Troniak 2009).

In December 2013, a new regional framework for nature conservation and protected areas in the Pacific Islands Region 2014–2020 was produced and adopted in the 9th Pacific Islands Conference on Nature Conservation and Protected Areas. The new framework provides guidance to NBSAPs in alignment with the global 2020 Aichi Biodiversity Targets, and reinforces the role of government, local communities and traditional knowledge and development partners to achieve conservation in the Pacific (SPREP 2014). The new framework introduced nine principles and a code of conduct for all conservation initiatives related to the implementation of Pacific Islands NBSAPs. The principles are: 1) community rights; 2) conservation from a Pacific perspective; 3) ownership of conservation programmes; 4) financial sustainability; 5) good governance; 6) coordination and collaboration; 7) capacity development; 8) accountability; and 9) reinforcing resilience and sustainability (SPREP 2014).

2.4 STAKEHOLDER INPUT

Government officials who participated in the MACBIO project (Appendix II: Stakeholder consultation and participant lists) saw this report as timely for Fiji in light of government commitments towards a green growth economy. The report will aid understanding of the value of marine resources and supporting ecosystem services and help government to reflect these values in policy decisions given the multiple benefits derived from marine resources. For example, data from this report will be used in the NBSAP.

Marine economic valuation can help Fiji meet its commitments under international agreements such as the Rio Declaration (1992), Barbados Program of Action (1994), Rio +10 (2002), Mauritius Strategy (2005) and Rio + 20 (2012). At the regional level, Fiji has also endorsed the Melanesian Spearhead Group (MSG) Declaration on Environment and Climate Change signed by the MSG leaders in 2012. In addition, Fiji also has a commitment to meeting the UN Millennium Development Goals towards sustainable and equitable development.

The Fiji Government has already developed a green growth framework under the aegis of the Ministry of Strategic Planning, National Development and Statistics in acknowledgement of international and regional commitments and in light of the need for sustainable development that incorporates environmental, social and economic concerns. The green growth framework was launched at the inaugural meeting of the Pacific Islands Development Forum in Nadi in 2013. Thus, most government departments and sections are obliged to initiate activities that support this direction of development. The guiding principles, such as reducing carbon footprints and adoption of environmental auditing measures, are areas to which this report can provide valuable input, despite its various gaps and limitations. This report provides the first comprehensive economic assessment of major coastal and marine ecosystem services for Fiji.

At the same time, the report identifies data gaps and bottlenecks within the current system that need to be addressed as the country moves towards integrated management under the green growth approach. In particular, our discussions with government staff identified the challenge presented by a major gap within the tourism data that needs to be addressed, especially because the sector is largely dependent on leisure and recreational activities that are entirely supported by the health of the marine ecosystem services such as diving, snorkelling and recreational fishing. There were suggestions for primary data collection on some of these activities to their *real* value. Officials within the tourism sector including the private sector individuals also realised the need for disaggregated data in this respect and the need to reflect *real* market values to avoid *externalities*.

Given the resource and capacity constraints within the Fisheries Department to gather timely data on estimations of values of resources such as licence fees, compensation to resource owners and other fees and charges, fisheries staff thought that the report would provide a useful background guide for comparative assessment and for harmonisation of potential conflicts or in determining trade-offs between uses of different ecosystems such as reef and mangrove areas. Based on the available data, they recognised that the study also identifies the *replacement cost* of the subsistence fishery which is useful information for supporting sustainable livelihood strategies. These data, they said, can also help support applications for external funds to focus more management attention on small rural coastal communities that are dependent on fisheries resources for food, particularly in the context of climate change adaptation.

Fiji is part of the REDD+ Programme⁶ which applies the 'ridge-to-reef' concept to protect forests as a means of benefitting from their conservation. The MACBIO study was seen as providing useful information about other ecosystems, such as estimates of the value of the carbon sequestration potential of mangroves, if mangroves become part of the programme.

Stakeholders thought the report included information of interest to most key sectors as well as national summaries, and provided an integrated and objective assessment of the relative value of different marine ecosystem services useful for interdepartmental exchanges and negotiations over issues about biodiversity loss or assessing potential benefits.

Some more specific uses of the report and results that have been identified for Fiji include:

- Contributing to a timely stock-take of the value of Fiji's major marine ecosystems and ecosystem services for national strategic planning purposes — e.g. formulating national development plans, fisheries sector plans, sustainable tourism plans
- Complementing and supporting environmental impact assessment (EIA) in coastal areas and helping calculate compensation payments for loss of resources between resource owners and developers or government and resource owners

6 REDD+ is a United Nations initiative aimed at Reducing Emissions from Deforestation and Forest Degradation.

- Helping to identify the costs of rehabilitation where ecosystems are already affected
- Promoting the prevention of degradation of important mangrove ecosystems
- Justifying for value assigned to coral reefs and their resources
- Identifying of acceptable limits to extraction of coastal resources such as amounts, scale of operation and/or appropriate regulations to monitor development activities — e.g. sand extraction, coral harvests, fish harvests
- Advocacy and raising awareness of types of data and information needs and identifying strategies for data collection about environment-inclusive growth — government, NGOs and other researchers
- Improving census data collection by Bureau of Statistics
- Improving pricing of ecosystem services such as diving, snorkelling and recreational fishing to reflect the true value of water-based tourism activities
- Assessing costs and benefits of fisheries resources to help determine licence fees, compensation to *qoliqoli* owners and other fees, charges and taxes such as export tax, environmental levies
- Helping determine trade-offs between uses of different ecosystems and economic activities such as commercial fisheries and aquaculture, biodiversity protection and economic development
- Providing support for policies advancing sustainable livelihood strategies such as enhancing sustainable fisheries for food security, e.g. support for FLMMA work and community-based projects
- Helping solicit external funds to support small rural coastal communities that are dependent on fisheries resources for food to protect their mangroves and seagrass beds for their multiple benefits (critical habitats, coastal protection, aesthetic values, etc.) and with climate change adaptation
- Helping the Ministry of National Planning to identify strategies to coordinate interdepartmental exchanges and negotiations on issues of biodiversity loss or assessing potential benefits, including allocation of resources, budgets and in assigning roles and responsibilities for different projects.



Coastal marine resources in Fiji are used and managed by locally organized communities or villages (*mataqali*).

2.5 RELATED PROJECTS AND INITIATIVES

There are a number of international, regional and sub-regional commitments, projects and/or initiatives that are relevant to this work.

The Framework for a Pacific Oceanscape (Pratt and Govan 2011) provides a regional context for implementing marine resource management within Fiji's waters, in particular through the Pacific Island Regional Ocean Policy 2009 (PIROP). The PIROP is intended to promote the Pacific region as an ocean environment in support of sustainable development. It is not a legal document, but its guiding principles are founded on international law, as reflected in UNCLOS and other international and regional agreements.

Sustainable use and conservation of marine and coastal biodiversity are priority action areas of the Strategic Plan of the CBD. The Pacific CBD member states, including Fiji, have expressed their commitment to the implementation of the extensive CBD resolutions on the conservation and sustainable use of marine and coastal biodiversity.

In this regard the project responds to the needs of Fiji by:

- assisting the government to achieve the Aichi targets as a contribution to the CBD Strategic Plan for Biodiversity 2011–2020
- implementing actions outlined in the country's NBSAP
- contributing directly to the CBD program of work on protected areas, especially to attainment of Aichi Target 11
- assisting with implementation of the CBD program of work on island biodiversity in accordance with the CBD COP 11 decision.

Beyond the CBD, Fiji has other commitments, interests and projects to which this report can contribute. For example:

- contributing to implementation of the Pacific Regional Environment Strategic Plan 2011–2015
- implementing some of the principles for regional integration and cooperation for the purpose of conserving marine resources formulated in the Pacific Oceanscape Framework and supported by high-level decision-makers
- initiating a System of Environmental-Economic Accounts (*green national accounting*)
- contributing to other projects, such as Ridge-to-Reef and RESCCUE (Restoration of Ecosystems Services against Climate Change Unfavourable Effects).

Through its implementation partners the MACBIO project is a member of the Marine Sector Working Group of the Pacific regional organisations (Pacific Island Forum Secretariat PIFS, SPREP, SPC, and USP) and locally active international environmental NGOs. This allows for project activities to be coordinated with projects in other target countries and to serve as an example in other Pacific Island States and Territories.

The transferability of successful approaches is enhanced by involving representatives of other regional institutions and by running workshops at regional events attended by all Pacific Island states, such as the Pacific Climate Change Roundtable and the Pacific Island Roundtable for Nature Conservation.

Dissemination of the knowledge gained from the project and its incorporation into global and regional processes is promoted through continuous dialogue with relevant global institutions (TEEB Global, UNEP World Conservation Monitoring Centre, EU Joint Research Centre, and IUCN World Commission on Protected Areas) and cooperation with ongoing BMUB International Climate Initiative projects in the field of marine and coastal biodiversity.

There are two regional initiatives aimed at the protection of marine and coastal resources that include Fiji: CRISP (Coral Reef Initiative for the Pacific) and the Asian Development Bank (ADB) Coral Triangle Pacific Program.

Coral Reef Initiative for the Pacific (CRISP)

The Initiative for the Protection and Management of Coral Reefs in the Pacific (CRISP) was sponsored by France and prepared by the French Development Agency (AFD) as part of an inter-ministerial project from 2002 onwards. CRISP covers 22 Pacific Island States and Territories, including the Fiji Islands. The objective of CRISP was to develop a vision for the future of these unique ecosystems and the communities that depend on them and to introduce strategies and projects to conserve their biodiversity, while developing the economic and environmental services that they provide both locally and globally. It is also designed to promote integration among developed countries (Australia, New Zealand, Japan and USA), French overseas territories and Pacific Island developing countries (Ram-Bidesi et al. 2011). The CRISP programme comprises three major components: integrated coastal and watershed management; development of coral ecosystems; and programme coordination (Table 2).

TABLE 2 • Components of the CRISP programme

Component	
1A	Integrated Coastal Management and Watershed Management
1A1	Marine biodiversity conservation planning
1A2	Marine Protected Areas
1A3	Institutional strengthening and networking
1A4	Integrated coastal reef zone and watershed management
2	Development of Coral Ecosystems
2A	Knowledge, monitoring and management of coral reef ecosystems
2B	Reef rehabilitation
2C	Bio-prospection and marine active substances
2D	Development of regional data base (ReefBase Pacific)
3	Programme Coordination and Development
3A	Institutional strengthening, technical support and extension
3B	Coordination, promotion and development of CRISP Programme

Source: Ram-Bidesi et al. 2011

ADB Coral Triangle Pacific Program

The Coral Triangle Pacific Program, Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (Phase II), ran from January 2011 to December 2014. The project aimed to improve the resilience of coastal and marine ecosystems and prepare them to adjust to climate change (ADB 2012). This was a US\$ 18.5 million dollar project financed by the ADB, and co-financed by the GEF, with the participation of five governments: Fiji, Papua New Guinea, Solomon Islands, Timor-Leste and Vanuatu. The objectives of the project included strengthening the capabilities of national and local institutions in sustainable coastal and marine resources management in the five countries and application of best practices in ecosystem-based fishery management and climate change adaptation by coastal communities (ADB 2012).

Although Fiji and Vanuatu are not part of the Coral Triangle Initiative, they share common environmental concerns about climate change under the GEF Pacific Alliance for Sustainability. The priority for Fiji was centred on building on lessons learned from past integrated coastal resources management attempts and on applying the FLMMMA model in Ba Province (ADB 2012). The project was executed by the DoE under the guidance of the government's Integrated Coastal Management Committee.

The project involved the participation of several collaborative partners. The International Food Policy Research Institute was responsible for studying the *economic impacts* of climate change on coastal and marine resources and preparing a development strategy for coastal communities in each country. The IUCN supported legal capability in the countries. The World Fish Centre was responsible for identifying potential adaptation approaches (guidelines and procedures) to help countries to respond to climate change (ADB 2012).

3 CONCEPTUAL FRAMEWORK

The primary purpose of this assessment was to provide decision-makers and policy-makers at all levels with information about the value that people place on their marine and coastal ecosystems. This was with a view to inform the development of decisions and policies with more concrete information about marine ecosystem values that are otherwise not fully appreciated or considered. For this reason, significant effort was made to conduct the work collaboratively, and with close interaction with key government and non-government stakeholders as well as technical staff within Fiji.

3.1 DEFINITIONS

Ecosystem

An *ecosystem* is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Natural ecosystems have varying attributes (e.g. particular species of plants and animals) and perform various functions (e.g. photosynthesis, chemical and nutrient cycling). Many of these attributes and functions benefit human activities, communities, and industries.

Ecosystem services

Ecosystem services are the benefits humans receive from the natural attributes and functions of ecosystems (cf. Figure 4). These benefits could be material goods such as timber or fish, or biological services such as the treatment of human waste and carbon sequestration.

The value of marine (and other) ecosystem services to people is often not visible in markets, business transactions or in national economic accounts. Their value is often only perceived when the services are diminished or lost. Assigning monetary values to marine ecosystem services to reflect their importance to Fijians is a powerful tool to make these benefits visible and improve their wise use and management. The process of assigning monetary values to ecosystem services that benefit people is called *economic valuation*.



FIGURE 4 • Marine ecosystem services

Economic value

Economic value refers to the quantified net benefit that humans derive from a good or service, whether or not there is a market and monetary transaction for the goods and services. *Economic value* needs to be distinguished from *economic activity* (also known as financial or exchange value), which is a measure of cash flows and is observed in markets⁷. While *economic activity* from market transactions is often used to calculate *economic value*, *economic activity* is not in and of itself a measure of human benefit. *Economic activity*, however, is an interesting measure⁸. The number of formal sector jobs and the likelihood of capital investment are closely related to *economic activity*, and this is of interest to the

7 Analysis of *economic activity* often focuses on 'multiplier effects', that is, the proportion of cash flows from one industry that spill over in to other industries due to inter-industry linkages.

8 GDP, produced through the System of National Accounts (SNA), is a measure of *economic activity*. The UN Statistics Division has recently published guidance for a System of Environmental-Economic Accounts (SEEA), which provides an accounting framework that is consistent and can be integrated with the structure, classifications, definitions and accounting rules of the SNA, thereby enabling the analysis of changes in natural capital, its contribution to the economy and the impacts of economic activities on it. It should be noted, however, that this system is restrictive in terms of the types of services and values that can be assessed.

public, civil servants and policy-makers. This report focuses on measuring *economic value*. Caution must be taken not to compare *economic activity* to *economic value*. Although both can be represented in dollars per year, they are different measurements of benefits.

In assessing and comparing ecosystem services, sometimes there are trade-offs to be made between different ecosystem services. For example, mining a coral reef for building materials will likely diminish its value as a source of food from fishing. Other ecosystem services can be complementary, for example, the coastal protection value of coral reefs and their tourism value from diving or snorkelling.

Consumer and producer surplus

In general, the analysis in this report is based on the microeconomic concepts of *consumer* and *producer surplus*. *Consumer* and *producer surplus* are net measures; they measure the difference between the benefits and the costs of a particular good or service. *Producer surplus* is the benefit received by businesses, firms, or individuals who sell a good or service; *consumer surplus* is the benefit received by individuals who purchase or freely enjoy a good or service. For market transactions, *producer surplus* is synonymous with *value-added* or *profit*.

Willingness-to-pay and willingness-to-accept

Benefits are quantified by an individual's *willingness-to-pay* (WTP) or a business's *willingness-to-accept*, or rather, how much money an individual or business would willingly trade for providing or receiving a good or service. The difference between consumers' maximum WTP and what they actually pay is the consumers' benefit from the transaction. Consumer WTP is represented graphically as a demand curve.

Total economic value

The *total economic value* of an ecosystem service includes all of the net benefits humans receive from that ecosystem service. *Total economic value* is a quantification of the full contribution ecosystems make to human wellbeing. *Total economic value* includes market and non-market values (i.e. *direct use value*, *indirect use value*, and *existence*, or *non-use value*) and therefore represents the full benefit humans receive from *ecosystem functions*. In practice, *total economic value* is nearly impossible to calculate because the data required to do so are rarely available. For example, fisheries resources offer benefits to those who harvest and sell seafood products (producers), as well as those who consume seafood products (consumers). The *total economic value* of the fishery is a sum of the producer and consumer benefits. However, consumer benefits are difficult to estimate and, in the case of export products, they accrue to individuals distant from the natural resource. Producer benefits alone are commonly used to estimate the value of fisheries, as is done in this report. It should be noted, however, that these estimates are a lower-bound value and do not represent *total economic value*.

Further definitions can be found in the glossary (Appendix I: Glossary).

3.2 THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY

As an implementing partner on the MACBIO project, IUCN Oceania is responsible for national assessment of marine and coastal ecosystem services in Fiji, Kiribati, Solomon Islands, Tonga, and Vanuatu. These national reports on marine and coastal ecosystem services follow the approach for assessing ecosystem services developed by the TEEB initiative (www.teebweb.org). The TEEB approach comprises six steps:

1. Specify and agree on the relevant policy issues with stakeholders
2. Identify the most relevant ecosystem services
3. Define information requirements and select appropriate methods
4. Quantify, then value, ecosystem services
5. Identify and appraise policy options and distributional impacts
6. Review, refine and report.

The MACBIO model for economic assessment of ecosystems was to conduct research in partnership with local organisations and government representatives to improve their capacity to analyse and synthesise ecosystem valuation data. This work, for example, was conducted by the USP in consultation with a range of government and non-government stakeholders as listed in Appendix II: Stakeholder consultation and participant lists. This collaborative approach

contributed to in-country understanding of, and belief in, the results of the *ecosystem service valuations*. Capacity development included discussions regarding resource economics concepts, recommendations for modifying or improving data collection, discussions about how economic service valuations could be used in government and elsewhere and ongoing monitoring and evaluation of ecosystem service values to achieve sustainable development. To this end, the *ecosystem service valuation* included the participation of government staff and local resource managers at every opportunity to permanently augment the capacity of country nationals to use ecosystem data and economic valuation in development of policies and resource management decision-making.

Stakeholder discussions were held to identify specific applications of the economic valuation in Fiji, including the policy issues that could be supported by more information about the values of ecosystem services (TEEB Step 1). The policy issues identified by stakeholders covered a wide range of topics. Given the resource constraints in these small countries, it was deemed unlikely that a detailed marine economic service valuation would be conducted for every policy context described. It was decided, therefore, to conduct a more generic marine *ecosystem service valuation* which could be used in whole or in part to inform a range of different existing and potential policy and decision-making situations in Fiji. These individual discussions and existing documentation helped to identify the most relevant ecosystem services per country (Step 2).

Steps 2–6 were conducted by IUCN staff with in-country colleagues following the approach of the TEEB initiative. TEEB encourages economic valuation practitioners to engage with stakeholders not just to identify needs and policy applications for the *ecosystem service valuation* but also to develop methods for valuation that meet those particular needs and to ensure that the data provided are useful and relevant. In addition, in-country colleagues advised about the best way to communicate the results to relevant stakeholders. This report forms the basis for any communication products.

A methodological guidance document (Salcone et al. 2015) was created in consultation with the country-based research teams in order to ensure as-consistent-as-possible treatment across the five study sites.

It is anticipated that this *baseline* report will provide a platform from which to identify priority actions — in terms of national policy development, national and watershed-scale data collection, regular analysis, planning and outreach — that better incorporate ecosystem service stocks, flows and values into ongoing national discussions and policy processes (Steps 5 and 6).

3.3 APPLICATIONS OF MARINE ECOSYSTEM SERVICE VALUATION

There are three main categories of applications of marine *ecosystem service valuation*: 1) to enable rational decision-making, via cost-benefit analyses or other analyses of the trade-offs of different management decisions; 2) as a technical tool to set prices for protecting resources or compensation for ecosystem damages; and 3) as general information, to raise awareness about the human benefits of healthy ecosystems and support policy and governance that manages resources from a social equity perspective (Mermet et al. 2014). The third application can lead to full integration of the benefits of ecosystems into national accounting (natural capital accounting). National-scale *ecosystem service valuation* is applicable mostly to this third use — general information for planning and advocacy.

Stakeholders identified the following explicit uses of the marine ecosystem valuation results in Fiji:

- Help compare the pros and cons of different marine resource uses
- Use data in policy decisions, e.g. in the National Biodiversity Strategy and Action Plan
- Support Fiji's Green Growth agenda and framework
- Help achieve some of Fiji's CBD commitments, e.g. Aichi Targets 1 and 2
- Contribute, more generally, to other international agreements aiming to promote more sustainable use of natural (including marine) resources
- Input to environmental audits
- Promote activities to reduce Fiji's carbon footprint, e.g. retention of mangroves
- Promote addressing critical data gaps, e.g. in tourism
- Support increases in government support for the government's marine resource managers
- Provide *baseline* data on marine ecosystem values against which future changes can be assessed

- Inform discussions about potential conflicts between marine resource use options
- Initiate use of payments for ecosystems services, e.g. for mangroves in terms of carbon sequestration (e.g. REDD+ type program)
- Inform interdepartmental discussions and negotiations on potential marine biodiversity losses or assessing the relative benefits of various marine resource use options.



4 LITERATURE REVIEW

Marine and coastal resources in Fiji suffer from overfishing pressure and overuse with consequent degradation (Teh et al. 2009). Besides overfishing, inshore reef fisheries are threatened by destructive and illegal fishing and pollution (Jennings and Lock 1996). The exploitation rate and possible overexploitation are correlated not only with the level of demographic growth but also with the availability of alternative subsistence and income options to villagers (Kronen et al. 2010a). Villagers have greater vulnerability the higher their dependence on limited coastal fishery resources (Kronen et al. 2010b). Reefs located in different parts of Fiji are subject to different degrees of fishing pressure, leading to a wide variation in the condition of reef fisheries (Teh et al. 2009). This fishing pressure is influenced by markets, increasing population and the need of households to meet the demands of an economy increasingly focused on monetary goods and services (Teh et al. 2009). Golden et al. (2014) identified commercial fishing to supply markets as the major driver of overfishing.

Due to progress and the migration of the rural population to urban areas, the traditional way that Fijians use marine resources has changed (deMers and Kahui 2011). These authors state that the country is still a long way from solving the overexploitation pressure on inshore and offshore marine resources. Since reefs under traditional systems of resource management been shown to be healthier (Hoffmann 2002), there have been calls for implementing sustainable management actions that include traditional knowledge. However, this is not necessarily easy to implement. Marine ecosystem protection and true integrated coastal zone management face a series of challenges in design of regulation, availability of ecological information on resources and their *economic value* and ways to integrate environmental constraints and local community needs into the government's management decisions (Austral Foundation 2007; Lane 2008; Jupiter et al. 2010; Mills et al. 2011b). For example, protected area management legislation could be improved to include the formal recognition and support of LMMAs (Techera and Troniak 2009).

Pollution is another issue in Fiji. Poor agricultural practices increase erosion and sedimentation in rivers and reefs (Zann 1994) and lead to clearing of wetlands and mangroves which act as buffer zones for flooding and sediment loads (Watling 1985). As a consequence of agricultural activities in Fiji's river basins, coral reef ecosystems have deteriorated. For example, Dadhich and Nadaoka (2012) found that 7.88% of forest land and 7.59% of grassland were converted to agriculture (10.04%), barren land (3.06%), pine plantations (1.68%) or industrial development areas (0.69%) in a study area of the northwest part of Viti Levu in the period 1992–2007. Most of the agricultural land was on steep slopes with low productivity. As a result, increased surface runoff and load of sediments were predicted. Using satellite imagery they found that coral cover was reduced by 33.5%, while algal and seagrass cover increased by 139%, indicating adverse impacts on reef conservation in the area. In another study, the load of sediments and nutrients decreased the mean clarity of waters in the bay of Suva Harbour and increased phytoplankton biomass (Zann 1994).

The level of pollution near populated areas can compromise the environmental quality of nearshore marine resources. In Suva, for example, in addition to industrial activity, there are two sewage treatment plants close to Laucala Bay. The plant at Kinoya directly discharges effluents into the bay via an outfall pipe 800 m offshore. The second plant at Raiwaqa discharges into Vatuwaqa River (Garimella et al. 2002). Studies around a city dump and a battery factory near Suva Harbour found that sediments and shellfish were sufficiently contaminated for the site to be considered a hazardous waste site (Naidu and Morrison 1994). In another study, Morrison et al. (1996) analysed 22 sediment and shellfish samples around Fiji for organochlorine pesticides and polychlorinated biphenyls; there were high concentrations of organochlorides around Suva and Lautoka. Contamination with metals in sediments and shellfish around Suva has been reported in several studies (e.g. Garimella et al. (2002) in Suva Lagoon (including Suva Harbour); Gangaiya et al. (2001) in the Lami estuary; and Maata and Singh (2008) in Suva Harbour). Levels of contamination in Suva Lagoon have increased (Garimella et al. 2002).

Much attention has been given to management strategies to address overuse, degradation and pollution of marine and coastal resources in Fiji. The FLMMA network and partners have focused on developing conservation initiatives for sustainable management of marine and coastal resources (Hughes et al. 2003; Lane 2008; Mills et al. 2011b; Hastings et al. 2012). Management areas under the FLMMA aim to incorporate traditional marine resource practices which have been shown to present advantages in contrast to other more contemporary management methods (Veitayaki 1997), resulting in a combination of traditional and contemporary methods of resource use (Veitayaki 2000). The integration of traditional knowledge into management of marine and coastal resources and local decision-making creates more sustainable resource use (Drew 2005; Cinner and Aswani 2007). Also, adaptive co-management strategies provide the

flexibility to adjust management objectives to a changing social, economic and environmental context, although higher transaction costs are incurred (Weeks and Jupiter 2013).

Two major categories of fisheries can be identified in Fiji: coastal (inshore) and oceanic (offshore). Fishing activities can also be classified by area (inshore/offshore) and scale (Gillet 2011). Small-scale commercial (or artisanal) and subsistence fishing are performed in coastal fisheries. Artisanal fishing can be further subdivided into fishing for local market and for export. Subsistence fishing is crucial for nutrition and food security in rural communities. Aquaculture has been expanding since 2010 due to improvements in technology and technical assistance, and can be considered a third category of coastal fisheries. Offshore fishing mainly targets tuna and other pelagic species and is undertaken in large industrial-scale fishing vessels. Offshore fishing can be classified as locally-based or foreign-based. The tuna industry dominates the sector in terms of output and exports. It is estimated that approximately 42% of the total catch of tuna is sold to canneries, 37% is sold as fresh fish exports and 21% is sold domestically (Fiji Fisheries Department 2013). The main offshore resources are four species of tuna and several species of bycatch including swordfish, marlin, dolphinfish, wahoo and sharks (Gillett 2011). Accounts of the historical development of Fiji’s tuna industry can be found in Ram-Bidesi (2003) and Barclay and Cartwright (2007).

Site-specific data and information on catch rates and yields of reef fisheries, biomass and ecological changes in coral reef ecosystems and socioeconomic conditions of coastal communities in Fiji are included in the following studies: Rawlinson et al. (1995); Jennings and Polunin (1995a); Jennings and Polunin (1995b); Jennings and Polunin (1996a); Jennings and Polunin (1996b); Kuster et al. (2005); and Turner et al. (2007). Studies by Passfield (1994) and O’Garra (2007) provide assessments of the value of coral reef fisheries in Fiji.

The Fiji NBSAP (DoE 2007) considers four major ecosystems as the base for the Fiji’s natural assets: 1) open sea (which, in terms of our report, supports offshore fisheries); 2) coral reefs, lagoons and beaches (which may be considered as coastal or inshore resources); 3) mangrove forests and estuaries (also part of coastal resources); and 4) tropical moist forests (that are out of the scope of our report but with clear links to marine resources through sediments and nutrients discharged to marine areas from erosion and agricultural activities in upper lands through streams and rivers). The NBSAP identifies 11 environmental services (Table 3) and also recognises that all ecosystems considered may provide many of the 11 environmental services simultaneously. The NBSAP does not distinguish clearly between those services that are relevant at a global level (e.g. climate regulation) or locally (e.g. waste treatment, food production).

TABLE 3 • Ecosystems and environmental services in Fiji identified in the National Biodiversity Strategic and Action Plan

Ecosystem	Environmental service
1. Open sea (offshore)	1. Climate regulation
2. Coral reefs, lagoons and beaches	2. Disturbance regulation
3. Mangrove forests and estuaries	3. Water regulation and supply
4. Tropical moist forests (included freshwater rivers and lakes)	4. Erosion control and soil formation
	5. Nutrient cycling
	6. Waste treatment
	7. Biodiversity preservation
	8. Food production
	9. Raw material provision
	10. Recreational opportunities
	11. Cultural values

Source: DoE 2007

Coastal communities in Fiji are significantly reliant on mangroves for their wellbeing and livelihoods. Mangroves produce a wide range of goods and environmental services which are used for both subsistence and commercial purposes (Thaman and Thaman 2001). Mangrove products and ecosystems provide ecological, cultural and economic functions to local communities, including firewood, construction materials, medicine, food, dyes and fishing equipment (Thaman and Thaman 2001). Another list of environmental goods and services from mangroves is provided by Watling (2013) (Table 4).

National estimates of the value of marine and coastal resources in Fiji are included in works by Lal (1990), Sisto (1999), Thaman and Thaman (2001) and O’Garra (2007, 2012). These studies relied partly on original survey data and analysis and partly on transferring value from international studies (e.g. Costanza et al. 1997). Further studies have relied on

values in these works; for example, Starkhouse (2009) and Lal (2003) used the estimates of Lal (1990), Agrawala et al. (2003) borrowed estimates from Lal (1990) and Sisto (1999). As part of collaborative research to understand the value of coral reef fisheries in Fiji, Starkhouse (2009) combined published data with primary data, Fisheries Department reports, expert interviews and other previous studies on coastal fisheries to estimate the value of subsistence and commercial catch from reef-associated fisheries in Fiji. Seidel and Lal (2010) borrowed value estimates from previous studies to prepare a regional report. Laurans et al. (2013) discussed the findings of valuation studies in the South Pacific and used estimates by O’Garra (2007, 2012) for Fiji.

TABLE 4 • Ecosystem services from mangroves

Ecosystem value	Description
Fisheries	The value of fish and shellfish supported by mangrove forests, including support as nursery and breeding grounds
Forestry	Includes timber, fuel wood, charcoal, and other forestry products
Recreation	Includes tourism and research expenditures
Storm protection	Coastal protection and stabilisation
Carbon sequestration	A recent estimate is that mangrove deforestation generates as much as 10% of emissions from deforestation globally, despite accounting for just 0.7% of tropical forest area
<i>Non-use values</i>	Including <i>option, bequest and existence values, or willingness-to-pay</i>
Purification	Water and air purification as well as waste assimilation
Nutrient	Nutrient retention and recycling
Biodiversity	Habitat value for species – marine and arboreal
Traditional/cultural uses	Reflects cultural uses

Source: Watling 2013

Table 5 summarises estimates of the value of Fiji’s ecosystems and their services from five previous studies (converted to December 2014 monetary terms using the consumer price index (CPI)). Some study outputs have been adapted to present unit values, e.g., per ha, per km² or per km of coast per year, in both Fijian and US dollars. The study by Lal (1990) focused on the value of outputs derived from mangrove forests. Considering the use of 32 ha of mangrove as oxidation ponds needed for a sewage treatment plant, the nutrient filtering services of mangroves was calculated by the alternative costs approach (Lal 1990). Lal considered information on 350 ha of mangroves at Raviravi and 242 ha of mangrove at Dreketi to provide an alternative estimation for food production values of mangroves. Calculations by Sisto (1999) were based on strong assumptions and previous studies. For example, for the climate regulation of open seas, the value of US\$ 38 per hectare per year (of 1994) (as carbon sinks) estimated by Costanza et al. (1997) was used. Thaman and Thaman (2001) reported on the value of all mangrove products used by a sample of households in Fiji (40 urban and 57 rural households). This study showed the importance of mangroves, especially for rural communities. According to a survey by the Fiji Bureau of Statistics (2011), there were 86,523 rural households and 88,724 urban households in Fiji in 2008. Assuming the same number of households in 2014, the total value of mangroves in 2014 would be at least FJ\$ 1,771.07 million per year (US\$ 886.65M) (Table 5).

Agrawala et al. (2003) presented values of the range of ecosystem goods and services in Viti Levu, including their role in subsistence and commercial fisheries (Table 5). However, the value ranges proposed seem to be based more on expertise of the technical team than on previous literature. For example, value for one hectare of mangrove was about FJ\$ 5,000 (US\$ 2,500). Given that all services they valued account for a range of FJ\$ 2,000 to FJ\$ 3,000 (2003 prices), the likely value of coastal protection was about FJ\$ 2,500 (See Table 5 for more details).

More recently, O’Garra (2012) estimated the *total economic value* of services from marine and coastal resources in Fiji. She identified subsistence and commercial fisheries as the most important services from coral reefs and mangrove ecosystems. Coastal protection from storms and flooding was the second most important service identified. O’Garra estimated the *total economic value* of coastal ecosystems and focused in the LMMA of Navacavu (13 km west of Suva). The *yavusa* Navacavu covers 580 km² of land and 18.5 km² of coastal waters. For coastal protection, O’Garra (2012) considered 8 km of coast and borrowed the estimate of US\$ 123,840 per metre per year from McKenzie et al. (2005) in 2005 prices. The relative contribution of mangroves was FJ\$ 2,500 per ha (in 2006 dollars).

TABLE 5 • Comparative value of ecosystem services adapted from previous studies in Fiji

Source	Ecosystem	Service	Area	Unit value*		Total value*	
				FJ\$/ha/yr	US\$/ha/yr	FJ\$/year	US\$/year
Lal 1990	Mangroves	Commercial fuelwood	38,500 ha	19.04	9.53	352,262	176,351
		Central Division		29.55	14.59		
		Western Division		14.05	7.03		
		Northern Division		13.53	6.77		
	Subsistence fuelwood		27.57	13.81	510,172	255,405	
	Food (Raviravi and Dreketi villages)		518.41	259.53	9,590,639	4,801,321	
	Inshore fisheries	670,400 ha	718.05	359.47	481,380,329	240,991,404	
Subsistence		375.83	188.15	251,958,760	126,137,052		
Commercial		342.22	171.32	229,421,569	114,854,352		
	Nutrient filter	32 ha	15,285.47	7,652.30	489,135	244,874	
Sisto 1999	Open Sea	Climate regulation	129m ha	108.73	54.44	14,026.70m	7,022.13m
		Food production (Offshore fisheries)		0.0048	0.0024	62.13m	31.11m
	Coral reefs, lagoons and beaches	Recreation	670,400 ha	975.6	488.4	654.04m	327.43m
		Disturbance regulation		891.97	446.54	597.98m	299.36m
		Subsistence fisheries		140.26	70.21	**	**
	Commercial fisheries	127.71	63.43	**	**		
	Mangroves	Food, nutrient cycling, habitat	38,500 ha	10,675	4,844	178.98m	136.56m
		Subsistence fisheries		5,083	2,545	94.03m	47.07m
		Commercial fisheries		5,592	2,299	84.95m	42.53m
		Disturbance regulation		4,866.37	2,436.23	187.36m	93.79m
	Tropical moist forest	Climate regulation	750,000 ha	638.47	328	478.85m	239.72m
		Water regulation and supply		40.10	20.07	30.07m	15.06m
		Raw materials provision		171.10	85.66	128.28m	64.22m
		Biodiversity preservation		28.61	14.33	21.47m	10.75m
Thaman and Thaman, 2001	Mangroves	<i>Total economic value</i>	38,500 ha	46,002	23,030	1,771.07m	886.65m
		-urban households		8,604	4,307	331.26m	165.84m
		-rural households		37,398	18,722	1,439.81m	720.81m
Agrawala et al. 2003	Mangroves	Subtotal excluding coastal protection	18,500 ha	3,099–4,649	1,552–2,328	57.34–86.01m	28.71–43.01m
		Fisheries total		620–1,085	310–543	11.47–20.07m	5.74–10.05m
		Subsistence		232–465	116–233	4.3–8.6m	2.15–4.31m
		Commercial		930	466	17.20m	8.61m
		Medicinal plants		232–465	116–233	4.3–8.6m	2.15–4.31m
		Habitat functions		232–775	116–389	4.3–14.3m	2.15–7.18m
Coastal protection	3,874	1,940	71.68m	35.88m			
<i>Total economic value</i> fisheries (100%)	1,823.34	907.84	3,354,796	1,678,897			
O'Garra 2007, 2012	<i>iQoliqoli</i> Navakavu	Commercial fisheries (57.3%)	1,850 ha	1,039.01	520.19	1,922,298	962,352
		Household consumption fish (24.6%)		446.10	223.33	825,280	413,156
		Gifts/sharing fish (18.2%)		328.23	164.32	607,218	303,389
		<i>Bequest value</i>		18.00	9.00	33,288	16,665
		Coastal protection	8 km	357,884	179,166	2,863,073	1,433,328
		Coral reefs	1,750 ha	1,434	718	2,509,516	1,256,328
		Mangroves	100 ha	3,536	1,770	353,557	177,000

* Values have been converted to terms of Dec 2014;

** Included with mangroves

5 METHODS

The general methods are presented in Salcone et al. (2015). Specific details of methods applied in this report are presented below or in the relevant sections of the report.

As far as possible, government staff and other relevant parties within Fiji worked with the authors to answer questions, supply information and data and to identify data gaps for this report (TEEB steps 1–4). See Appendix II: Stakeholder consultation and participant lists for the list of people consulted. These colleagues also identified in-country policies, plans, strategies and other marine resource management tools to which this work could contribute (see Section 2).

5.1 OVERVIEW OF ESTIMATION METHODS

This analysis identified seven key marine and coastal ecosystem services that are described and valued in this report.

1. Subsistence food
2. Commercial food
3. Minerals and aggregate
4. Tourism and recreation
5. Coastal protection
6. Carbon sequestration
7. Environmental research, management and education

Marine and coastal ecosystems provide many more ecosystem services than the seven explored here. These seven were identified as nationally important, potentially quantifiable with existing data and amenable to policy intervention or private action.

The detailed and specific mathematical methods and data requirements for estimating the value of these seven marine and coastal ecosystem services are provided in Salcone et al. (2015). This is a methodological guidance document created in consultation with the country-based research teams and other Pacific resource economists to ensure consistent treatment across the five study sites.

Where sufficient data are available, *ecosystem service valuation* represents producer and/or *consumer surplus* and includes market and non-market values for direct and indirect ecosystem services. Where sufficient data do not exist to implement the most appropriate methods, the next best possible ecological-economic analysis has been conducted. This may include qualitative descriptors of values or references to other locations with data on the identified values. Gaps in data and previous research are partially offset with the authors' judgment based on economic theory.

Introductions to specific methods used to value each of these seven ecosystem services are given in Chapter 6.

Unless otherwise stated, all values have been converted to 2014 US dollars (US\$) or Fiji dollars (FJ\$). Currencies are converted using the most appropriate method to facilitate comparison of the magnitude of the benefits or costs using price or currency *inflation* indices. Throughout the report an exchange rate of US\$ 1 = FJ\$ 1.9975 is used.

5.2 SECONDARY DATA SOURCES AND QUALITY

We consider an evaluation of marine and coastal resources in Fiji based on information previously prepared and published by government agencies, international organisations and NGOs and academics. We prioritised collection of data from project reports that collected primary data, such as from sampling surveys, direct observation and interviews with stakeholders. We avoid opinion-based data and make our assumptions explicit to assure a higher level of accuracy and reliability of our calculations.

5.3 DATA GAP ANALYSIS

We explicitly analyse the availability of information and value estimates for each ecosystem service. We identify, quantify and then estimate value of each ecosystem service. Data gaps are discussed in the **Uncertainty** section for each ecosystem service, where we discuss strengths and limitations of estimated values and data availability. We provide recommendations on data gaps to be filled by further research.

5.4 SYNTHESIS AND EXTRAPOLATION

Since this report aims at evaluating the availability of information on value, we do not attempt to estimate value by using value transfer. However, we use other values as reference to provide context, using values converted to US dollars at 2014 prices.



6 RESULTS

This chapter includes the identification, quantification, and where possible, valuation of Fiji's most significant marine and coastal ecosystem services. The first subsection for each ecosystem service, **Identify**, describes the ecosystem service and the relation between the ecological or biological processes of that ecosystem (the *ecosystem functions*) and the human benefits (the *ecosystem services*). This subsection also describes the human activities and livelihoods that are related to the ecosystem service. The second subsection, **Quantify**, describes data that illustrate the magnitude of the service either in monetary units or ecological measures and evaluates data gaps. Where sufficient data could be collected, the third subsection, **Value**, presents the *economic value* of the ecosystem service. The value represents a quantification of human benefits in terms of local monetary currency.

The **Sustainability** and **Distribution** of ecosystem service benefits is evaluated following the valuation of each service. It is important to understand whether human benefits can be maintained or if they are expected to decrease because of unsustainable resource use or management practices. It is also important to recognise who receives the benefits from the ecosystem, whether it be poor or wealthy households, government, visitors or foreign nations. The **Uncertainty** of each value estimate is also discussed in this section.

6.1 SUBSISTENCE FISHERIES

Subsistence fishing refers to using marine and coastal resources to supply food to local populations, rather than selling the products. Subsistence fishing is when fish is consumed by the fisher or their family, given as gift or bartered locally (Kronen et al. 2007). In Pacific Island countries, coral reef fisheries are characterised by a strong predominance of fishing for subsistence with an estimated 80% of coastal fisheries catch consumed directly by the fisher and their communities (Adams et al. 1995). Recent studies indicate a decline in fish consumption associated with households of higher economic status (Turner et al. 2007; Teh et al. 2009).

6.1.1 IDENTIFY

Subsistence fishing is mostly carried out on patch reefs, fringing reefs, lagoons, mangrove and estuarine areas (Rawlinson et al. 1995). Subsistence landings are frequently underestimated or missing entirely from national statistics (World Bank 2000; Zeller et al. 2014). Women and children play an active role in the subsistence fishery. Fijian households rely on subsistence fishing, especially when unemployment becomes an issue. For example, Fay-Sauni et al. (2008) found that, near the delta of Rewa River, in Nadoria Village, subsistence fishing by women is important because of the high level of unemployment. According to the study, subsistence fishing was more important than commercial fishing for families. The role of women in fisheries has profound implications for management, poverty alleviation and



Locally organized communities traditionally control very well delimited portions of marine areas as customary fishing grounds (*iQoliqoli*).

development policy. Women have a major role in subsistence fishing, which may account for 56% of annual small-scale catches (Harper et al. 2013). Harper et al. (2013) emphasised the importance of using the ecological knowledge of women in fisheries management and in policies related to food security, biodiversity, conservation and climate change. Traditionally, women's participation in fishing is much higher in inshore and coastal areas than men's, while men dominate in fishing activities beyond the reef (Lambeth et al. 2002). Lambeth et al. (2002) estimated that 70–80% of catch from inshore fisheries was used for subsistence.

6.1.2 QUANTIFY

Rawlinson et al. (1995) estimated that 45% of rural households in Viti Levu were located less than 5 km from the coast. They found that 99.3% of the population consumed marine products at least once a week. Marine products and tinned fish were consumed at 65% of meals, primarily at midday and in the evening, with a consumption rate of fish products of 68.2 kg/person/year.

There are no recent national studies on subsistence fisheries in Fiji. The ADB estimated subsistence fishery employment as 3,000 full-time fisher equivalents in Fiji (ADB 2005; Gillett 2009). The United Nations Food and Agricultural Organization (FAO) estimated that there were 30,000 subsistence fishers in Fiji (FAO 2008). In 2003, the subsistence fishery was estimated to contribute FJ\$ 48.6 million to total GDP while the artisanal commercial sector contributed F\$ 27.6 million by value (Hand et al. 2005). The Fiji Fisheries Department used 'value to the consumer' as a measure of the subsistence fishery's *economic value*, estimating it at US\$ 7.2 million in 2002 (Fiji Fisheries Department 2003).

One of the first attempts to assess the value of production for the subsistence fishery in Fiji was by the Fiji Fisheries Department in 1978–1979 in a survey that interviewed approximately 7% of coastal villages about their average catch. Based on the survey, a national estimate of subsistence fishery in 1979 was 13,826 tonnes (Fiji Fisheries Division 1979). Indeed, the 2003 estimate of the value of the national subsistence fishery (Fiji Fisheries Department 2003) was based on extrapolation of data from the 1979 study. Starkhouse (2009) outlined the shortcomings of using this method which added 200 tonnes to the previous year's catch each year.

A survey of subsistence fishing on Viti Levu estimated the catch for the island as 3,515 tonnes per year (Rawlinson et al. 1995). While the study was comprehensive, it only covered one island and thus it could not be used to represent the whole country. A study conducted by the World Bank differentiated between finfish and invertebrates in the subsistence fishery, with finfish contributing 11,015 tonnes per year and invertebrates as much as 7,042 tonnes per year (World Bank 2000). Starkhouse (2009) estimated the quantity and value of the subsistence fishery in Fiji using detailed interviews in 12 villages in Viti Levu, Yasawa Islands, Kadavu and Vanua Levu and modelling the responses using Monte Carlo simulations. The subsistence catch was estimated as: $[\text{catch} = \text{fishers} \cdot \text{CPUE} \cdot \text{freq} \cdot \text{wks}]$ where 'fishers' was the number of fishers that retained some portion of their catch for subsistence purposes, 'CPUE' was the catch per unit effort (kg per trip), 'freq' was the weekly fishing frequency (trips per week), and 'wks' was the number of fishing weeks per year (Starkhouse 2009). Since food tends to be a market good, and given the lack of information on non-market goods in the country, the more straightforward approach to obtain a value estimate is by quantifying catch (total and per capita), assuming a level of consumption per capita and borrowing market exchange prices from local markets. In this way, Starkhouse (2009) was able to estimate a value in monetary terms.

6.1.3 VALUE

Estimates of the value of subsistence fishery vary depending on the time period of the study and method chosen. This study uses the research data from Starkhouse (2009) to calculate the value of subsistence fisheries attributable to the provisioning services of coastal ecosystems. Other studies have also relied on Starkhouse (2009) because of its comprehensive coverage and robust methodology (e.g. Gillett 2009; Fiji Fisheries Department 2011, 2013).

Starkhouse (2009) estimated the national average subsistence catch to be 15,186 tonnes consisting of 10,405 tonnes of finfish and 4,782 tonnes of invertebrates, giving 68% catch as finfish and 32% as invertebrates. Using this information together with data on per capita consumption of fish and fishery products (Bell et al. 2009) and population census data for 2014, the total production of the subsistence fishery in Fiji in 2014 is estimated as 15,385 tonnes, comprising 10,462 tonnes of finfish and 4,923 tonnes of invertebrates.

Given that there is no direct method to value the subsistence fishery, the production value was estimated using consumption data from the Household Income and Expenditure Survey (HIES) (Bell et al. 2009; Fiji Bureau of Statistics 2011) to determine the subsistence surplus, although as argued by Bell et al. 2009, HIES data often underestimates the level of subsistence production. Nevertheless, it is a better reflection of the *real* consumption than the harvest estimates above given that there are varied post-harvest losses which make it difficult to calculate actual consumption quantities. Thus, based on 2014 population and fish per capita consumption estimates for Fiji, the subsistence production is estimated in Table 6.

TABLE 6 • Estimating subsistence production for 2014

Estimated population (2014): 865,716 consisting of 441,515 (51%) urban and 424,201 (rural) ¹	
Annual per capita fish consumption (HIES data) ² : Urban: 15 kg Rural: 25.3 kg	
% Annual per capita consumption derived from subsistence ³	Urban population x consumption rate = 1.05 kg/person/year Rural Population x consumption rate = 13.16 kg/person/year Total consumption for 865,716 people: Rural: 13.16 kg x 424,201 = 5,582,485 kg Urban: 1.05 kg x 441,515 = 463,590.75 kg Total change in consumption = rural + urban: 6,046,075.75 kg Assume 68% finfish and 32% invertebrates based on Starkhouse (2009)
Urban population : 7% Rural population: 52%	
Total estimated subsistence catch consumed = 6,046,076 kg	Total subsistence finfish = 4,111,332 kg Invertebrates = 1,934,744 kg

1 Fiji Bureau of Statistics 2014a; 2, 3 Bell et al. 2009

The value of subsistence fishing can be calculated by subtracting the costs of fishing from the expense of buying an equivalent protein food. Equivalent protein food, as the most common replacement or substitute, is taken as canned mackerel or canned tuna because they are readily available even in the most remote places. The residual value is known as subsistence surplus since producer and *consumer surplus* is the same in this case.

$$\text{Subsistence Surplus} = (\text{Subsistence Harvest kg} * \text{Price Protein Equivalent } \$/\text{kg}) - \text{Harvest Costs } \$$$

Based on the World Bank (2000) method for converting subsistence fish production into equivalent protein consumption and adjusting to current population estimates from the Fiji Bureau of Statistics, the gross annual value of equivalent protein is approximately FJ\$ 82.08 million (Table 7).

TABLE 7 • Equivalent protein calculation using 2014 Fiji dollars

Finfish conversion ¹ : 19.5 grams of protein per 100 grams of finfish Invertebrate conversion (assumed that this largely consists of shellfish) 11.2 grams of protein per 100 grams of shellfish	112 g per kg invertebrates 195 g per kg of finfish	801,709,740 g protein 216,691,328 g protein Total protein equivalent = 1,018,401,068 g
Substitute consumption ² : 50% canned tuna 50% canned mackerel	(509,200,534 g /100) *19.5 canned tuna (509,200,534 g/100)*11.2 canned mackerel	425 g canned mackerel = FJ\$ 3.50 ³ 170 g canned tuna = FJ\$ 2.60
	Price per g of mackerel = FJ\$ 0.0082 Price per g of tuna = FJ\$ 0.153	
	Value of equivalent protein: canned tuna= FJ\$ 77,907,682 mackerel = FJ\$ 4,175,443	Total subsistence protein equivalent FJ\$ 77,907,682 + FJ\$ 4,175,443 FJ\$ 82,083,125
		Estimated gross value of equivalent protein for replacement of subsistence fishery = FJ\$ 82,083,125

1,2 World Bank 2000, annex;

3 average retail price

Harvest costs

The total cost of the subsistence fishery in 2008 was estimated by Starkhouse (2009) as US\$ 15.2 million, with *intermediate costs* totalling US\$ 5.9 million. Using April 2008 average exchange rate of US\$ 1 ~ FJ\$ 1.473, these estimates convert to FJ\$ 22.39 million and FJ\$ 8.69 million, respectively. Therefore, adjusting harvest cost to 2014 values, the cost would be FJ\$ 23.04 million given the current rate of *inflation* of 2.9% with 2008 as the base year.

The subsistence surplus is therefore estimated as FJ\$ 82,083,125 minus FJ\$ 23.04 million, a total of FJ\$ 59.04 million per year.

6.1.4 UNCERTAINTY

Starkhouse (2009) used market prices to estimate the gross value of subsistence fishing at US\$ 31.0 million (FJ\$ 45.7 million) and gave a net value of US\$ 15.8 million (FJ\$ 23.3 million). Gillett (2009) estimated the value of subsistence fishing as FJ\$ 54.1 million.

Fish and marine product prices have been rising in the local markets and the Fiji Fisheries Department (2013) used FJ\$ 7.50 per kg as the average price of fish. Production volume is assumed to be twice the live weight of fish. Converting consumption of 6,046,075 kg to live weight of fish gives a production estimate of 12,092 tonnes. This estimate gives the gross value of subsistence as FJ\$ 90.7 million. Using this gross value and current market price of FJ\$ 7.50 per kg, the average value of subsistence fishery is close to FJ\$ 13,527.91 per km² of reef.

Compared to previous estimates of the value of subsistence fisheries (Starkhouse 2009; Gillett 2011), Table 7 gives a higher value for subsistence fishing even though the quantity of production estimate is lower. However, earlier estimates relied on market values of fish rather than replacement values of substitute protein, which gives a higher value for economic surplus of subsistence fishing. The gross value per km² of reef is also high because of the current high market price of fish and other marine products.

6.1.5 SUSTAINABILITY

The limited available information indicates that the inshore and nearshore finfish and invertebrates in many areas of Fiji are overexploited (Gillett 2014). Such a threat to the subsistence fishery is a major concern in terms of the ability of the fishery to meet the nutritional and food security needs of Pacific Island countries including Fiji, as highlighted in the study by Bell et al. (2009). Jennings and Lock (1996) warned almost 20 years ago that many of Fiji's inshore reef fisheries were already threatened by overfishing, destructive and illegal fishing and pollution.

The rise in value of the subsistence fishery does not necessarily indicate a healthy situation because the value is reflected by rising prices that are used in valuation as well as in *replacement costs*. Modernisation and the demand for cash are putting increasing pressure on coastal communities to sell part of their subsistence catch in the face of declining stocks.

6.1.6 DISTRIBUTION

In Fiji, there are 410 *iQoliqoli* that primarily benefit fishing rights owners. Other people living along the coastal areas and settlements also frequently either poach or seek permission to fish in these areas. The extent of either of these practices is unknown. In addition, cultural practices of rural coastal communities commonly include visiting urban areas for education, medical reasons and holidays or for temporary work, bringing with them fresh marine products either for their immediate consumption or as gifts for relatives. No studies have been done to estimate the value of marine products in this practice.

6.2 COMMERCIAL FISHERIES

Commercial fishing refers to fishing for marine products that are sold in markets. In Fiji, there are two major types of commercial fisheries: artisanal/coastal commercial fishery (inshore); and the oceanic tuna fishery (offshore). The quantities and values of these types of fisheries are discussed separately.

6.2.1 INSHORE FISHERIES

6.2.1.1 IDENTIFY

Small-scale commercial (or artisanal) fishing can be divided into fishing for local markets or for export. Fish production and market data are collected by division and efforts are being made to centralise this information. Data on catch landings are collected from market outlets which include municipal markets, roadside stalls, hotels, restaurants, shops and butchers. The domestic artisanal fishery data only include catch from the two main islands (Viti Levu and Vanua Levu) where about 88% of the population lives (Fiji Bureau of Statistics 2014a).

Production of artisanal fish based on market surveys collected by divisions are not currently compiled to produce national estimates by species as was done prior to 2005 due to resource constraints (senior fisheries officers, pers. comm.). Thus divisional data are not publicly available. The only national data available on total domestic artisanal production disaggregated by species was for 2005 in the Central, Western and Northern Divisions, approximately 96% of the population of Fiji (Table 8, Table 9).

The largest invertebrate fishery in Fiji is the freshwater clam fishery, accounting for 64% of the total invertebrate fishery (Table 10). Marine ecosystems directly contribute a smaller portion of invertebrate fishery, but have much greater biodiversity because of the wide variety of species caught. Each species is only present in small numbers, indicating their vulnerability to increasing fishing pressure.

6.2.1.2 QUANTIFY

Domestic artisanal catch of finfish and non-fish (invertebrates and other aquatic products for 2010) is shown in Table 10. The value of finfish in 2010 was estimated as FJ\$ 36.6 million while the value of other catch was FJ\$ 10 million (Fiji Fisheries Department 2011). The average market price of finfish was recorded as FJ\$ 7.50 per kg by the Fisheries Department in 2013 (Fiji Fisheries Department 2014).



Subsistence and commercial fisheries are, economically, amongst the most important ecosystem services derived from coral reefs and mangroves.

TABLE 8 • Fish catch in artisanal fisheries by species in Central, Western and Northern Divisions, 2005

Fijian name	English name	Scientific name	Catch (tonnes)
Nuqa	Rabbit fish / Spine foot	<i>Siganus spinus / vermiculatus</i>	176
Saqa	Trevally	<i>Caranx sp.</i>	140
Dokonivudi	Long-nose emperor	<i>Lethrinus olivaceus</i>	143
Ulavi	Parrotfish	<i>Scarus/Cholorurus/Cetoscarus sp.</i>	126
Kanace	Bluespot mullet	<i>Valamugil seheli</i>	126
Salala	Chub mackerel	<i>Rastrelliger kanagurta</i>	123
Kawakawa	Peacock rockcod	<i>Cephalopholis argus</i>	119
Walu	Spanish mackerel	<i>Scomberomorus commerson</i>	108
Donu	Coral trout	<i>Plectropomus sp.</i>	105
Kabatia	Thumbprint emperor	<i>Lethrinus harak</i>	99
Sabutu	Yellow-tailed emperor	<i>Lethrinus mahsena</i>	94
Kawago	Spangled emperor	<i>Lethrinus nebulosus</i>	93
Ta	Yellowfin surgeonfish	<i>Naso unicornis</i>	79
Damu	Mangrove Jack	<i>Lutjanus argentimacalatus</i>	70
Oqo/Silasila	Barracuda	<i>Sphyaena qenie / barracuda</i>	70
Kasala	Spotted fin cod / marbled cod	<i>Epinephelus polyphekadion</i>	63
Balagi	Surgeonfish	<i>Acanthurus mata</i>	61
Wau	Wahoo	<i>Acanthocybium solandri</i>	62
Kalia	Double-headed parrotfish	<i>Bolbometopon muricatus</i>	60
Opakapaka	Snapper	<i>Pristipomoides sp.</i>	60
Sevaseva	Harlequin sweetlip	<i>Plectorhinchus chaetodonoides</i>	60
Mollissa			56
Bo	Paddletail snapper	<i>Lutjanus gibbus</i>	62
Kacika	Slender emperor	<i>Lethrinus xanthochilus</i>	48
Rosinibogi	Scarlet seaperch	<i>Lutjanus timoriensis</i>	48
Mama	Large-eyed bream	<i>Gymnocranius robinsoni / Monotaxis grandoculis</i>	47
Senikawakawa	Honeycomb rockcod	<i>Epinephilus merra</i>	46
Drekeni	Brown sweetlip	<i>Plectorhinchus nigra</i>	44
Cumu	Triggerfish	<i>Psedobalistes sp. / Balistapus sp.</i>	44
Kake	Blue-lined snapper, black-spot seaperch	<i>Lutjanus quinquelineatus / Lutjanus fulviflamma</i>	43
Bati	Red bass	<i>Lutjanus bohar</i>	41
Ose	Goatfish	<i>Mulloidichthys vanicolensis</i>	41
Reve	Orange-spotted therapon perch	<i>Mesopristes kneri</i>	40
Qitawa	Crescent perch	<i>Terapon jarbua</i>	40
Kaikai	Pony fish	<i>Leiognathus equulus / Gazza minuta</i>	39
Saku	Long tom	<i>Tylosurus crocodilus</i>	38
Utouto	Green jobfish	<i>Aprion virescans</i>	36
Ikadroka	Flagtail	<i>Kuhlia rupestris</i>	34
Uluqa	Kusakars snapper	<i>Paracaesio kusakarii</i>	33
Total			2,817

Source: Fiji Fisheries Department 2006

TABLE 9 • Invertebrate catch from artisanal fisheries by species for Central, Western and Northern Divisions, 2005

Fijian name	English name	Scientific name	Catch (tonnes)
Kai	Freshwater clam	<i>Batissa violacea</i>	1396 ^a
Kaikoso	Ark shell	<i>Anadara cornea</i>	115
Nama	Sea grapes	<i>Caulerpa racemosa</i>	114
Qari	Green mangrove crab	<i>Scylla paramamosain</i>	102
Uraudina	Painted rock lobster	<i>Panulirus versicolor</i>	86
Uradina	Freshwater prawn	<i>Macrobrachium sp.</i>	55
Sucuwalu	White teatfish	<i>Holothuria fuscogilva</i>	50
Dri	Sea cucumber	<i>Stichopus/Actinopyga sp.</i>	37
Lairo	Land crab	<i>Cardisoma carnifex</i>	30
Mana	Mud lobster	<i>Thalassina anomala</i>	27
Kukaloa	Black mangrove crab	<i>Metopograpsus messor</i>	27
Cawaki	Sea urchin	<i>Tripneustes gratilla</i>	26
Kukadamu	Red-clawed crab	<i>Sesarma erythroductyla</i>	24
Ura/ Moci	Mangrove crab	<i>Palaemon concinnus</i>	22
Kuita	Octopus	<i>Octopus sp.</i>	22
Kaidawa	Hardshell clam	<i>Periglypta puerpera</i>	9
Lumicevata	Mainehair	<i>Hypnea nidifica</i>	7
Yaga	Spider shell	<i>Lambis lambis</i>	6
Dairo	Sandfish	<i>Holothuria scabra</i>	5
Lasawa	Turban shell	<i>Turbo chrysostomus</i>	5
Katavatu	Rugose giant clam	<i>Tridacna maxima</i>	5
Golea	Stromb	<i>Strombus gibberulus</i>	5
Bale	Giant tiger prawn	<i>Penaeus monodon</i>	3
Tavutolu	Three-spotted reef crab	<i>Carpilius maculatus</i>	3
Vasuadina	Smooth giant clam	<i>Tridacna derasa</i>	3
Madrali	Polished nerite	<i>Nerita polita</i>	2
Tovu	Top shell	<i>Trochus pyramis</i>	2
Total (marine only)			2,188 ^b

a The freshwater clam (kai) fishery is not a marine fishery.

b The total is for marine invertebrate fisheries, excluding the freshwater clam (kai) fishery.

Source: Fiji Fisheries Department 2006

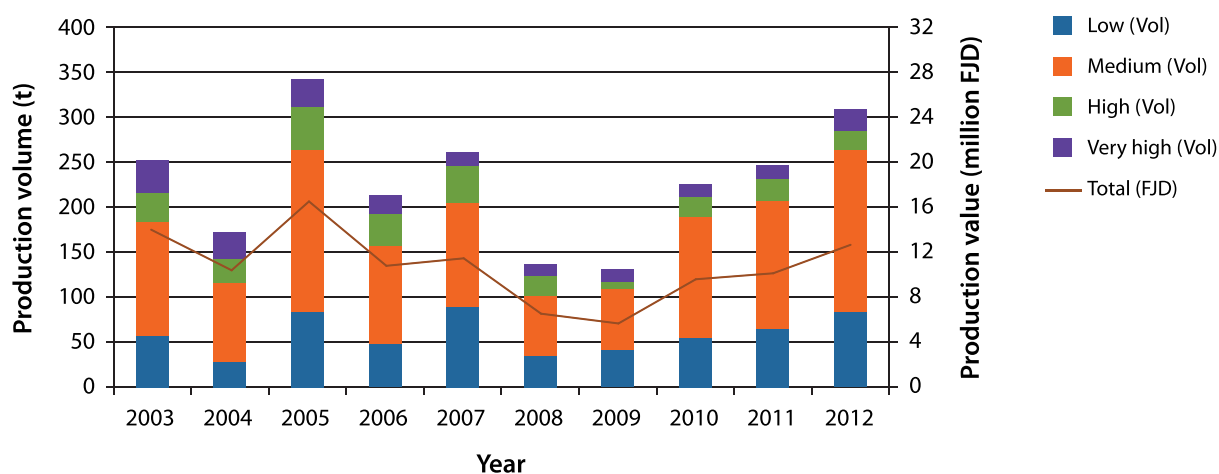
TABLE 10 • Coastal finfish and non-fish production in 2010

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Inshore finfish (tonnes)	1,200	1,180	1,050	1,320	4,750
Inshore non-fish (tonnes)	450	870	500	800	2,620

Source: Fiji Fisheries Department 2011

In 2008, the artisanal catch landing of the two main islands was 4,886 tonnes of finfish which was valued at FJ\$ 24.7 million, while non-fish production was 2,724 tonnes and was valued at FJ\$ 9.3 million (Fiji Fisheries Department 2009). With this production, the average market price for finfish in 2008 can be estimated to be FJ\$ 5.05 per kg. Note that there was a slight reduction in the catch of finfish in 2010 compared to 2008 but that there was an increase in the average market price for finfish by 48% in the two years reflecting an increased demand for finfish.

The only recent detailed data on quantity and export value is for the *bêche-de-mer* fishery, a fishery of high commercial importance in the artisanal commercial sector (Pakoa et al. 2013). Nationally, the sea cucumber (live or unprocessed) fishery is Fiji's second most important commercial fishery after tuna. The fishery has boom-and-bust characteristics (Figure 5). The official statistics appear to underestimate the number of companies involved in the industry; in 2009, there were 19 companies involved in processing and exports of *bêche-de-mer* in Fiji (Pakoa et al. 2013). The production status and issues of this fishery are briefly discussed in Gillett (2011) and Govan (2013). From 2003 to 2012, the annual volume and value of the *bêche-de-mer* production varied significantly from a low of 130 tonnes in 2009 to peak of 340 tonnes in 2005, giving an annual gross value of FJ\$ 5.5 million to FJ\$ 16.5 million respectively, thus demonstrating the boom-and-bust cycle within even short period of time (Figure 5; Pakoa et al. 2013). This volume is higher than the production volumes given in Table 10, due to underestimates in the data collection from 2005 as explained in Pakoa et al. (2013).



Low, medium, high and very high refer to the quality of *bêche-de-mer*. Source: Pakoa et al. 2013

FIGURE 5 • Production (tonnes) and value (FJ\$ million) of the *bêche-de-mer* fishery in Fiji, 2003–2012

The decline in the overall artisanal wild capture fishery, which includes *bêche-de-mer*, has been attributed to overexploitation, destruction of habitats and pollution (Gillett 2011, 2014; Govan 2013).

6.2.1.3 VALUE

The value of commercial fishing is the sum of *producer surplus* of businesses and individuals selling fish and *consumer surplus* of individuals purchasing and eating fish.

$$\text{Producer surplus} = \text{Commercial Fishing Revenue}_{\$} - \text{Commercial Fishing costs}_{\$}$$

The gross value of the artisanal fishery has been estimated by Gillett (2009) as FJ\$ 54 million for 9,500 tonnes in 2009 dollars. Starkhouse provided a more detailed assessment of the part-time and full-time nature of the artisanal fishery. Based on his estimates, the value of the artisanal (reef-associated fishery) had a gross value of US\$ 33.4–49.2 million in 2009 prices. The costs associated with fishing are the *intermediate costs* associated with harvesting and include such costs as fuel, labour and food; fuel costs are very high because fishers often travel significant distances (Starkhouse 2009). The net benefits for part-time fishers ranged US\$ 611–1,637 per person per year and there were an estimated 2,033 part-time fishers. Therefore the value of the artisanal fishery for part-time fishers was US\$ 1,242,163–3,328,021 (Starkhouse 2009).

There are an estimated 4,643 full-time fishers. The net benefits for full-time fishers range from US\$ 1,019 to US\$ 4,023 per fisher, giving a total value of US\$ 4,731,217–18,678,789. Combining the net annual benefits of part-time and full-time fishers gives a range in value of US\$ 5,973,380–22,006,810 (in 2009 dollars). Converted to 2014 dollars that is approximately FJ\$ 14,572,097 (US\$ 7,295,167) as a minimum estimate for both part-time and full-time fishers and a maximum estimate of FJ\$ 53,685,747 (US\$ 26,876,469). Given the best available information, these estimates by Starkhouse (2009) are the most reliable for calculating net benefits from the artisanal commercial fishery.

The gross value estimates of Gillett (2009) are higher because Starkhouse (2009) did not include the estuarine bivalve *Anadara corea*, as it is not a reef-associated species. The list of reef-associated fish and invertebrates that he considered also did not include the high-value mud crab, *Serrata paramamosain*, or other crab species, since the study was focused on reef-associated species. Thus, there is a major gap in estimating the total value of artisanal commercial fisheries associated with marine ecosystems. An estimate of the number of fishers using estuarine areas such as mangroves would remedy the lack.

A study by O'Garra (2007) on Navakavu *qoliqoli* estimated the gross value of fishing and gleaning as FJ\$ 12,847 per household per year. The study also estimated the cost per fisher as FJ\$ 601. Using these cost and *revenue* estimates and taking into consideration the number of licensed artisanal fishers in 2013 (2,538) as a proxy for the total number of coastal commercial fishers (Fiji Fisheries Department 2014), gives an estimate of *producer surplus* of FJ\$ 31,080,348 (the *gross revenue* minus the harvesting cost multiplied by the number of licensed fishers and adjusted to 2014 prices).

Given the limitations of the data, the *producer surplus* of the artisanal fishery (in 2014), including the *bêche-de-mer* fishery, is estimated as ranging from FJ\$ 14,572,097 (US\$ 7,295,167) to FJ\$ 53,685,747 (US\$ 26,876,469).

The reef area of Fiji is 6,704 km². Using only the reef-based species of the artisanal commercial fishery, the average fish and invertebrate production value is FJ\$ 21.74 (US\$ 10.88) to FJ\$ 80.08 (US\$ 40.09) per hectare of coral reef per year (using data from Starkhouse 2009). Note that the true value is likely to be higher if the subsistence component of the artisanal fishery is included.

6.2.1.4 UNCERTAINTY

There is a high degree of uncertainty in the estimates due to reliance on data from few studies and lack of availability of national market data on price and quantity by species. Prices of fish and invertebrates have been rising along with the cost of operations such as fuel costs (Fiji Fisheries Department 2014).

Note also that the main estimates used by Starkhouse (2009) exclude many artisanal commercial species known to be important, particularly crabs and inshore pelagic fish such as mackerel. The focus of this study is on marine ecosystems, thus excludes the freshwater kai fishery which represents 64% of the invertebrate fishery in Fiji. Therefore these estimates should be used cautiously as they are under-representative of the total volume or value of the national artisanal commercial fishery. In addition, Starkhouse (2009) extrapolated his findings from studies of 12 villages; there are over 800 villages in Fiji.

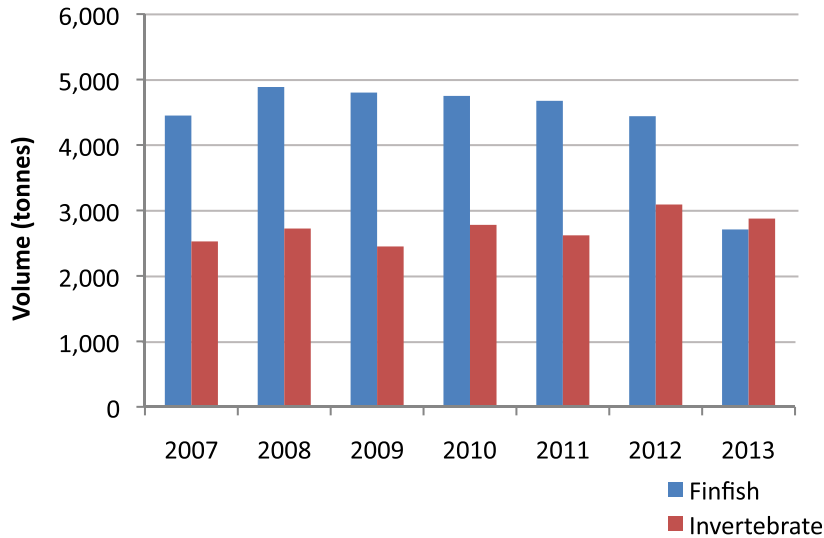
The commercial artisanal fishery is constantly changing due to changes in key drivers such as improvements in technology, designation of protected areas, high employment rates in rural areas and changing lifestyle. Therefore the true *economic value* of this fishery should be assessed with regard to these factors in light of its *opportunity costs*. It would also be helpful if data for the artisanal fishery distinguished the freshwater fishery from the marine fishery so that adequate policy attention is given to both, realising the importance of the freshwater fishery for inland people and recognising the extreme fragility of low populations of coastal marine invertebrates.

6.2.1.5 SUSTAINABILITY

The limited information available indicates that inshore and nearshore finfish and invertebrates in many areas of Fiji are overexploited (Gillett 2014). The decline in the artisanal wild capture fishery in general has been attributed to overexploitation, destruction of habitats and pollution (Gillett 2011, 2014; Govan 2013).

The Fiji Fisheries Department has been working with NGOs and other institutions to address the issue of resource sustainability. A number of LMMAs have been declared by communities to help in local conservation and management of important fish stocks. The overall effect of LMMAs on sustainability cannot be established without a national production status report for the artisanal fishery. Anecdotal information indicates that stocks are declining, the size of fish sold (e.g. mullet) is much smaller than previously and there is a reduced supply of lobsters, giant clams and groupers such as cods. At the time of this study, no data was available on trends for different species.

Export trends of *bêche-de-mer*, used as a proxy for production, indicate that this subcomponent of the small-scale inshore fishing industry is characterised by a boom-and-bust cycle and is not ecologically sustainable. While recent national fish stock data by species are not available, production trends demonstrate a declining trend in finfish (Figure 6). There has been a decline in production of finfish from 4,886 tonnes in 2008 to 2,710 tonnes in 2013, despite increasing population pressure and increasing access to local markets.



Source: Fiji Fisheries Department 2014

FIGURE 6 • Volume of coastal artisanal commercial fisheries in Fiji, 2007-2013

Production and value trends for invertebrates have remained stable because data include freshwater clams or kai (Figure 7). We were unable to distinguish trends for marine invertebrates because disaggregated data by species is unavailable after 2005.



Source: Fiji Fisheries Department 2014

FIGURE 7 • Value of artisanal commercial fisheries in Fiji, 2007-2013

6.2.1.6 DISTRIBUTION

The artisanal commercial fishery is essentially production from rural areas that supplies domestic urban markets. A number of artisanal fishers are also semi-subsistence operators who keep part of the catch for home consumption. The sector clearly demonstrates a strong rural–urban link and *value-added* production has potential to grow, particularly mariculture production such as pearls or seaweeds. The *value-added* could be in the form of traditional processing and preservation such as smoking, drying and/or making into gourmet products such as fish cakes and fish balls by cooking and adding other ingredients.

6.2.2 OFFSHORE FISHERIES

Accounts of the historical development of Fiji's tuna industry can be found in Ram-Bidesi (2003) and Barclay and Cartwright (2007). The SPC Oceanic Fisheries Programme compiles and estimates the annual catch and effort data for oceanic target tuna species, billfish species and non-target species. The tuna industry in Fiji began with the establishment of a pole-and-line fishery in the late 1970s, but the industry switched to longline by the early 1990s (Lightfoot 1998). The Pacific Fishing Company (Pafco) is the main tuna processing plant located on the Island of Ovalau and is the major employer on the island. Much of the raw materials supplied to Pafco come from foreign vessels fishing outside Fiji's EEZ although some domestic vessels also supply frozen albacore from time to time.

Tuna catch data from SPC are often aggregated by vessel flag and thus include data on catch from outside Fiji's EEZ in Fiji's catch. Therefore, catch from national waters was obtained from FFA which relies on observer data and fishing log books to determine the spatial area of catch.

6.2.2.1 IDENTIFY

The tuna industry in Fiji has been faced with a number of problems relating to fluctuations in supply and competition from foreign fleets, as well as a general decline in high-value species such as bigeye and yellowfin tuna (Hand et al. 2005). In addition, there has been a sharp increase in fuel prices, which has also caused a number of vessels to remain in port for extended periods during the fishing season. Fiji, therefore, has increasingly relied on tuna caught outside the EEZ to continue operations of its five processing plants. The allocation of tuna fishing licences within Fiji's EEZ has been a contentious issue for some time. There are two parallel industry associations: the Fiji Tuna Boat Owners' Association, and the Fiji Offshore Fisheries Association (FOFA). The former largely relies on export of fresh chilled tuna, while the latter consists of various forms of joint venture operations that supply domestic markets and export processed and frozen fish. A number of foreign companies are involved in domestic tuna harvesting and processing operations under the FOFA.

Data on tuna fisheries catch in Fiji can be obtained from regional databases, but data on the economics of vessels operations, markets and resource status are either limited or not available in a consistent manner to make any comparative analysis.

The main offshore resources are four species of tuna and several species of bycatch including swordfish, marlins, dolphinfish, wahoo and sharks (Gillett 2011). The three main tuna species harvested are albacore, yellowfin and bigeye. The catch composition recorded in 2010 was 70–80% albacore, 15–25% yellowfin and 8% bycatch (Fiji Fisheries Department 2012). The tuna industry dominates offshore commercial fisheries in terms of output and exports. It is estimated that about 42% of the total catch of tuna is sold to canneries, 37% as fresh fish exports, and 21% as domestic sales (Fiji Fisheries Department 2012).

6.2.2.2 QUANTIFY

Data on tuna catch in Fiji's national waters (EEZ) and value of catch taken in national waters is provided by the FFA. Table 11 shows the summary of total tuna catch and value in Fiji's waters. Table 12 summarises the number of fishing licences given to tuna fishing vessels.

TABLE 11 • Total annual catch and value of tuna in Fiji national waters, 2004–2013

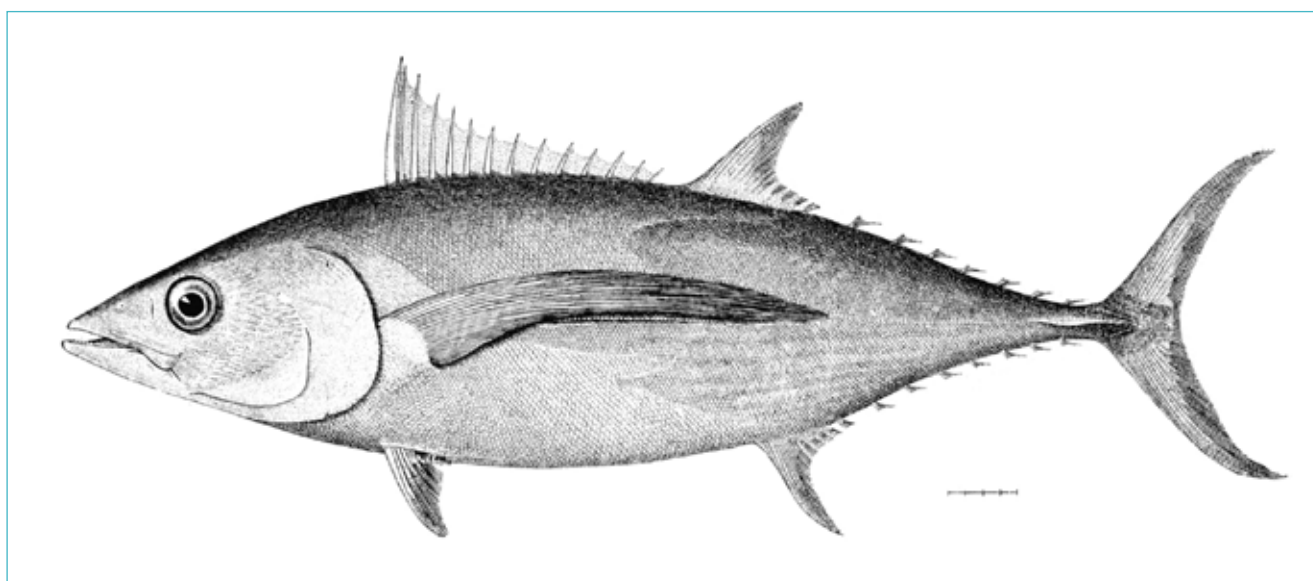
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Catch (million tonnes)	10,654	8,772	8,709	6,030	7,578	8,363	6,887	8,608	8,137	6,297
Value (US\$ million)	35	27	30	18	27	31	25	41	40	24

Source: FFA database 2014

TABLE 12 • Number of tuna fishing vessels licensed to fish in Fiji's EEZ

Year	Number of licences
2005	72
2006	68
2007	57
2008	46
2009	58
2010	58

Source: Fiji Fisheries Department 2012



Albacore Tuna, Wikimedia Commons.

In the Fiji Fisheries Annual Report for 2010 (Fiji Fisheries Department, 2012), data are presented by vessel flag, which includes Fiji registered and flagged vessels that also fish outside of Fiji's EEZ, which may include domestic vessels and locally-based foreign vessels that land their catch in local ports. Table 13, for example, presents catch estimates by species from 2006 to 2010. Catches reported were higher because fish caught outside of Fiji's EEZ by Fiji-flagged vessels are included in the totals. For example in 2010, almost 58% of the catch was from outside of Fiji's EEZ. This study, however, is focused on estimating the value of Fiji's marine resources excluding that caught outside Fiji's EEZ.

TABLE 13 • Estimates of catch by species for domestic longline vessels (tonnes)

Catch (tonnes) by domestic longline vessels					
Species	2006	2007	2008	2009	2010
Albacore	11,802	7,145	7,650	7,166	8,221
Bigeye	771	556	671	689	657
Yellowfin	1,231	1,721	2,763	2,564	2,777
Swordfish	223	105	183	97	104
Blue marlin	217	109	344	101	244
Black marlin	16	19	139	44	34
Striped marlin	123	57	60	34	62
Mahimahi	561	233	317	287	345
Wahoo	694	359	489	501	611
Shark	1,601	743	992	1419	1,701
Other	2,468	1,370	708	947	1,657
Total	20,707	12,417	14,316	13,849	16,413

Source: Ministry of Fisheries and Forests 2014

The total estimated production of tuna in Fijian waters (EEZ) by local and foreign-based vessels in 2013 was 6,297 tonnes, valued at US\$ 24,125,009 (FJ\$ 48,177,642 in 2014 dollars)(FFA database 2014).

Deriving operational costs from oceanic or tuna fishing operators has always been a challenge. Costs varied depending on the nature of fishing operations including days at sea, size and capacity of vessels, and cost of inputs such as labour and fuel.

Gillett (2009) estimated the gross value of tuna catch in 2007 in Fijian waters by the Fiji National Tuna Fleet as FJ\$ 55.14 million while foreign fleet catch in Fiji waters was estimated at FJ\$ 843,564, thus giving a total gross value of FJ\$ 55,983,564 (FJ\$ 77,242,390 or US\$ 38,669,532 in 2014 dollars).

Data from the tuna fishery indicate that a large proportion of the tuna catch landed in Fiji by Fiji-flagged vessels comes from outside Fiji's EEZ (Figure 8). The overall catch level has been maintained over time, despite declining catches of bigeye tuna because catches of albacore have increased (Gibson 2014). For Fiji, there are now clear trends of declining tuna stocks due to overfishing within the EEZ (Gibson 2014).

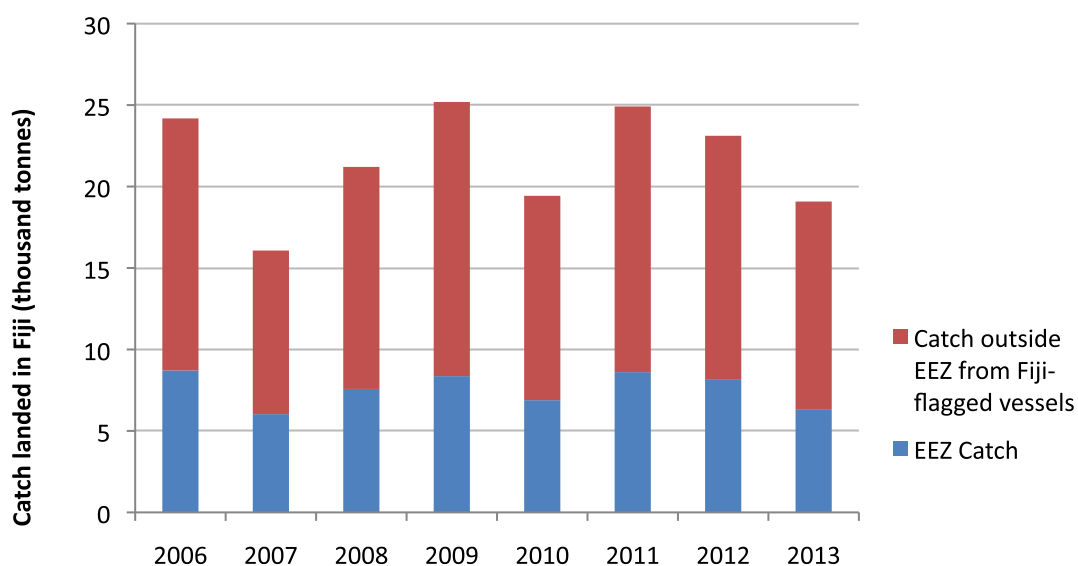


FIGURE 8 • Tuna catch within Fiji EEZ (blue) and by Fiji-flagged vessels outside the EEZ (red), 2006–2013

6.2.2.3 VALUE

It is usually convenient to express the *intermediate costs* as a proportion of the gross output (Philipson 2006). For large-scale offshore fisheries, the *value-added* ratio lies in the range of 40–55% (Gillett and Lightfoot 2001). In fact, the Fiji Offshore Fisheries Council estimated that the *value-added* ratio was around 45% (Gillett and Lightfoot 2001). Thus, taking 50% as representing the cost of operations, the net benefit from oceanic tuna fishing is estimated at FJ\$ 19,541,257 in 2013 prices (FFA database 2014), which converts to FJ\$ 20,107,954 (US\$ 10,066,560) in 2014 prices.

Alternative estimates of the cost of production were also derived from a bioeconomic study of Fiji's tuna fishery. The cost per hook was estimated as FJ\$ 1.85 which included labour and capital *opportunity cost* as well as other operating costs (FFA 2012). The study estimated that a vessel sets about 2,500 hooks and fishes for about 240 days a year with a total annual effort of 600,000 hooks. Some 64% of the vessels' effort was in national waters which gives a total of 384,000 hooks per vessel. There were 58 licences in 2010 giving an estimated total cost of FJ\$ 41,203,200.

Using the estimated gross value of FJ\$ 55 million and the estimated cost of FJ\$ 41 million, the net benefit is FJ\$ 14 million using 2010 data based on the FFA bioeconomic study (FFA 2012). Using 2013 data from FFA gives a net benefit of FJ\$ 20.11 (US\$ 10.07) million in 2014 prices.

Fiji's EEZ is approximately 1,290,000 km² while the total net value of catch from the EEZ is FJ\$ 20,107,954 (US\$ 10,066,560), thus giving an average net return of FJ\$ 0.16 (US\$ 0.08) per ha of EEZ.

The 2014 net benefit from the tuna fishery in Fiji's EEZ is estimated as FJ\$ 20,107,954 (US\$ 10,066,560).

6.2.2.4 UNCERTAINTY

The value of tuna fishery is uncertain for a number of reasons. First, the tuna stock is highly migratory, and thus is dependent on regional and sub-regional stock movement and population size. Data by national jurisdiction, therefore, presents high levels of uncertainty due to the difficulty in separating the stock by national boundaries. Second, climatic fluctuations have a direct impact on stock migration patterns, thus some years have very low catches because of tuna movement.

Data on the operating costs of tuna vessels are not available and estimates are based on reports from the FFA. These reports are a few years old and therefore estimates of costs may not represent a true reflection of the *real* costs today.

6.2.2.5 SUSTAINABILITY

The Review of Fiji's National Tuna Management and Development Plan (FFA and SPC 2012) clearly outlines the concerns of the domestic tuna industry. A provisional total allowable catch (TAC) of 15,000 tonnes has been determined by SPC. However, the TAC has not been reached within Fiji's EEZ and licence numbers for vessels remain low. Catches of high-value bigeye tuna, which was previously the target species for the sashimi market, have diminished because the fishery has become unviable, leading to fishers switching effort to albacore and other tuna species.

The company director of a prominent tuna fishing and processing company indicated that he had diverted some of his vessels to the deep water snapper fishery because of current very low tuna catches so the business could remain viable (G. Southwick, pers. comm., 24 November 2014). In addition, there is also criticism about the large number of licences issued to highly subsidised Chinese vessels that compete against unsubsidised, locally owned vessels.

6.2.2.6 DISTRIBUTION

Tuna is largely an export-oriented industry where the majority of the nutritional benefits accrue to the importing countries. Local employment opportunities are created in the domestic economy through engagement in the harvesting, processing and marketing sectors and other linked industries associated with tuna such as the service sector.

6.3 DEEP-SEA AND AGGREGATE MINING

Deep-sea and aggregate mining refers to the consumptive use (extraction) of mineral and aggregate goods for domestic or commercial purposes. Sand, gravel and limestone are in high demand in Fiji for construction (building roads and houses).

6.3.1 IDENTIFY

6.3.1.1 DEEP-SEA MINERALS

Deep-sea mineral resources include polymetallic nodules, polymetallic seafloor massive sulphides and cobalt-rich ferromanganese crusts (ISA 2014).

Polymetallic manganese nodules vary between 2 and 15 cm in diameter (DORD 2015). They are formed from iron and manganese hydroxides and are located at depths between 4,000 and 6,500 metres (UNEP 2014). Polymetallic manganese nodules are mostly composed of manganese oxide (ISA 2014). Apart from manganese and iron they can contain nickel, copper and lithium (UNEP 2014) and cobalt (DORD 2015).

Seafloor massive sulphides are created by hydrothermal activity when volcanic lava at high temperatures is released at the seabed (UNEP 2014). Their metalliferous muds contain copper, zinc, lead, iron, silver and gold (ISA 2014) and rare metals such as germanium and gallium (DORD 2015). Most of these deposits are located within the Fiji EEZ but some are also found in international waters (UNEP 2014).

Cobalt-rich ferromanganese crusts are hard, solid layers of volcanic origin up to 25 cm thick formed from precipitation of manganese and iron over the surfaces of seamounts, ridges and plateaus at water depths between 400 and 7,000 metres (UNE 2014). Apart from iron, manganese and cobalt, they may also contain nickel (UNEP 2014) and platinum (DORD 2015).

The presence of cobalt-rich crusts and polymetallic sulphide deposits has already been detected in the North Fiji Basin (Atalifo et al. 2012).

The Committee for Coordination of Offshore Prospecting — South Pacific Applied Geoscience Commission (CCOP-SOPAC) has conducted exploratory work on marine-based minerals, oils and gas, under a joint regional and international initiative of the United Nations. No seabed mining is currently undertaken in Fiji, although there are frequent requests for permits for exploration from private foreign investors. For example, in 2011, there were 17 deep-sea mineral exploration licences issued compared to 50 for the same period for exploration on land (Finau 2011).

Exploration for minerals has not been limited to metals. In Fiji there has also been an interest in petroleum. From 1971, exploration has targeted the shallow-water sedimentary basins (Howorth 1997). Exploration offshore and on Viti Levu from 1980 to 1982 reported anomalous amounts of pentane in seabed sediments off northern Viti Levu, suggesting the presence of thermogenic hydrocarbons (Howorth 1997). In 1993, a natural oil seep in South Bligh Water raised interest in exploration for possible oil (SOPAC 1998). In 1999, SOPAC was part of the Japanese Deep-Sea programme which organised two survey trips to assess the potential for polymetallic sulphide deposits in the North Fiji Basin. In addition, there has been subsequent interest, including from Australian and Canadian private companies, in exploring Fiji's EEZ and continental shelf areas. Offshore exploration is still at an early stage, but surveys so far reveal presence of polymetallic massive sulphides (rich in copper, zinc, lead, gold, silver) in Fiji's EEZ in water depths of about 2,500 metres (SOPAC 1998). In August 2011, Nautilus Minerals of Canada acquired 14 special prospecting licences to explore the potential mineral deposits in an exploration area that covers 60,000 km² of ocean floor; the licences were each valid for two years. The company expected to find underwater deposits of high-grade copper, gold, silver, and zinc (Shi 2012).

Deep-sea mining was not a possibility when the Fijian legislation was first established. In addition, concerns have been raised about resolution of conflicts in offshore waters. In 2007, Fiji placed a moratorium on exploration licenses until offshore mineral policy was formulated and adopted (Finau 2012). The *Mining Act (Amendment) 2010* was passed on 20 July 2010. It enables "the granting of special prospecting licences in respect to the seabed and for that purpose to provide a grid system for such prospecting purposes" (Government of Fiji 2010). The offshore mineral policy included legal modification to the definition of land (to include the seabed lands), an exploration fees scheme, and provisions to include Fiji nationals on board, and access to material collected and all methods used for exploration, as applied through Marine Scientific Research provisions under UNCLOS. Decree Number 21 of 2013, on international seabed minerals management was enacted in 2013. This decree describes the legal framework for seabed mineral activities, including seabed minerals extraction. The decree also establishes the International Seabed Authority (ISA) as the organisation through which State Parties to UNCLOS shall organise and control seabed mineral activities (Government of Fiji 2013). Environmental issues derived from deep-sea mining are seen as problems to be solved.

6.3.1.2 SAND AND AGGREGATES

Aggregates (gravel and sand) come from rivers and coastal zones. Reef/beach sand is used for construction and as an ingredient for cement production. The extraction of aggregates has a long history in Fiji, paralleling colonisation and economic development of the country. Unfortunately, no government records are available for aggregate extraction, presumably because sand and gravel extraction may be considered an informal activity and is not necessarily tracked by authorities.

In Fiji, mining and extraction of sand and gravel is still predominantly land-based. Sand and gravel extraction takes place in rivers and streams. However, as demand for construction increases and activities on land come under greater regulatory control, it is possible that coastal areas may become more regulated if adequate management controls are not put in place.

The two main mining activities in coastal areas are extraction of coral sand for construction and the extraction of hard coral that is used for filtration in septic tank systems. Extraction activities are localised and sometimes occur in the reef lagoon, but no records are available to determine the scale of operation or the size of the market. Coastal beach mining for aggregates is uncommon, although unreported localised extraction activities do occur.

There are currently two cement manufacturing companies in Fiji that supply construction cement not only to the local market but also to other Pacific Island countries. The Pacific Cement Company located in Veisari, Lami indicated that local coastal sand is not used as a raw material. An interview with a senior technical officer indicated that use of dredged coastal sand has been halted since 2005 and all raw materials are imported (Senior Technical Officer, Pacific Cement Co, pers. comm., 22 December 2014). The company website also states that coral sand is no longer dredged from Suva Harbour (Pacific Cement 2014). The Tengy Cement (Fiji) Company Limited started operation in mid-2014. A senior company representative neither denied nor confirmed the use of coral sand obtained from nearby areas and indicated that information on raw materials was confidential (Senior Manager, Tengy Cement Co, pers. comm., 23 December 2014). However, the extraction of aggregates for the cement industry has been a problem in the past. For example, Howorth (1997) reported mining of coral sand at Laucala Bay in the 1990s (Howorth 1997).

The iconic Sigatoka sand dunes, declared a National Park in 1987, have been subjected to illegal take as construction material. Sand aggregates were extracted for manufacture of cement prior to 2005.

6.3.2 QUANTIFY

6.3.2.1 DEEP-SEA MINERALS

There is increasing interest in exploration for minerals deposited on the seabed of the Fijian EEZ. Since 1985 a series of scientific missions have broadly described the seabed mineral assets in Fiji (Table 14; SRK Consulting 2007).

TABLE 14 • Summary of seabed exploration cruises to the North Fiji Basin, Fiji

Expedition name	Ship	Dates
SEAPSO III Avant Cruise	RV Jean Charcot	1985
STARMER Kaiyo 88	RV Kaiyo	November –December 1987
STARMER I	RV Nadir/Nautile	June 1989
STARMER Kaiyo 89	RV Kaiyo	1989
NEW STARMER NOFI 94	RV L'Atalante	September 1994
STARMER	Yokosuka	January – February 1990
STARMER	Yokosuka/Shinkai	August – September 1991
NEW STARMER	RV L'Atalante	September 1994
Hyfiflux SO 99	RV Sonne	January 1995
Hyfiflux II SO 134	RV Sonne	August 1998
SOPAC-Japan Project	Yokosuka	1999
TRIPLE JUNCTION	Yokosuka	2001
Ridge 2000 Expedition 4 of 5	RV Melville	May–June 2005

Source: SRK Consulting 2007

By the end of May 2013, three mining companies/institutions had been granted permission to explore the deep sea in the Fijian EEZ, involving a total of 17 licences (Figure 9; ECORYS 2014). They were KIOST, Nautilus Minerals and Bluewater minerals (Radio New Zealand International 2013). In spite of concerns and opposition to deep-sea mining, the Fijian government argued that issuing exploration licences offered the opportunity for updated information on seabed resources.

Nautilus was the first company granted permission for deep-sea exploration in Fiji, for an initial term of two years. In 2006, Nautilus applied for two exploration licences, the first for 4,900 ha and an annual rent of FJ\$ 3,260 (in 2006 prices) and the second for 241,200 ha and an annual rent of FJ\$ 137,656 (in 2006 prices), for five years. They can be extended for a maximum of 20 years (SRK Consulting 2007).



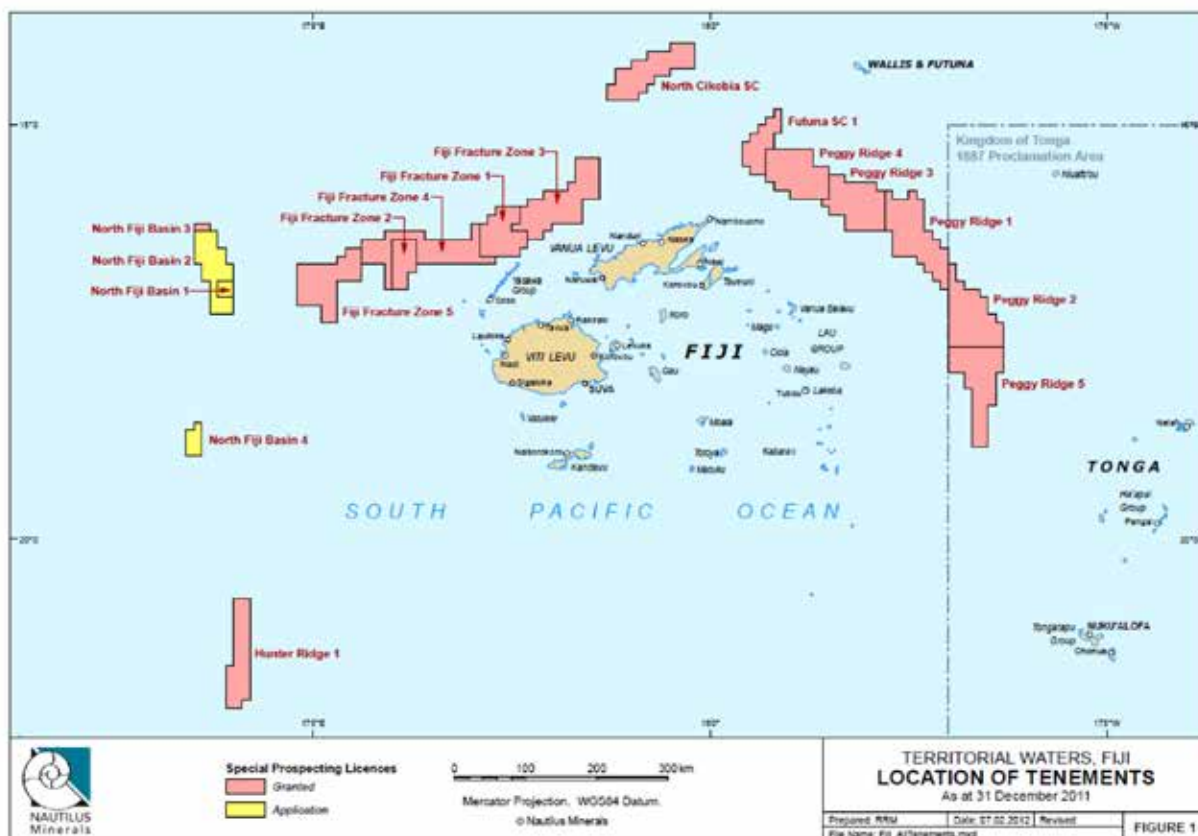


FIGURE 9 • Deep-sea exploration tenements in Fiji

Source: ECORYS 2014

Given that there is limited research and local technical capability to engage in further development in this area, there is a need for international cooperation with private investors. The role of the government is therefore critical in ensuring that legal and environmental regulations are put in place to ensure fair returns to all stakeholders and adequate protection of Fiji's environment and resources.

6.3.2.2 SAND AND AGGREGATES

The exact role of the different government departments in the case of mining of coral sand is not clear because such activities fall within the remit of multiple agencies: Fisheries Department (in so far as the activity impacts fisheries); iTaukei Affairs (level of compensation and distribution of rent); Lands and Mineral Resources (sand is not considered a mineral resource but as a part of extension of land/seabed). No reports specifically on mining of coral sand could be obtained from any of these departments since their operations are still very sector-based.

Coral sand has been dredged from the reef at Laucala Beach (Suva) since 1962 as a major input for producing cement. Cement is produced for local market and for export to other Pacific Island countries. The extraction averaged 70,000 cubic metres annually in 1990–1996 (Howorth 1997).

Evidence of extraction is seen along the Coral Coast where there are stockpiles of hard coral visible by the road side. The only information available was reported in the U.S. Geological Survey Minerals Yearbook for Fiji (Table 15; Shi 2012, 2014). However, these data do not distinguish between production/extraction from marine or land-based sources.

TABLE 15 • Estimated production of selected mineral commodities

Commodity	Unit	2007	2008	2009	2010	2011	2012	2013
Cement, hydraulic	tonnes	145,000	143,000	110,000	120,000	120,000	120,000	130,000
Limestone	tonnes	220,000	250,000	215,000	50,000	50,000	50,000	60,000
Sand and gravel	m ³	310,000	300,000	300,000	300,000	300,000		

Source: Shi 2012, 2014

6.3.3 VALUE

The value of deep-sea mining and coastal mining of sand and aggregates is difficult to ascertain because deep-sea mining has not yet started and coastal mining data are not collected by any specific official agency.

6.3.3.1 DEEP-SEA MINING

To our knowledge there is no estimation on the endowment of seabed minerals in the EEZ of Fiji. The focus of companies to date has been to collect samples to estimate the magnitude of seabed mineral deposits. The extraction costs are also unknown. However, the government has established a structure of exploration fees (Table 16).

TABLE 16 • Fee structure for the administration of licences for deep-sea mineral exploration in Fiji

	Initial fee per block	Revised fee
Application fee for exploration license	189	189
Annual license fee per block (Term 1)	114	2,283
Preparation fee for exploration licence (EL)	758	758
Application for extension of exploration license (Term 2)	378	378
Annual license fee Term 2 (per block)	228	4,566
Application for extension of exploration license (Term 3)	342	11,922
Application for prospector's right	152	152
Filing application for approval of transfer (Term 1)	1,334	1,334
Filing application for approval of transfer (Term 2)	2,668	2,668
Filing application for approval of transfer (Term 3)	6,670	6,670
Deposit of duplicate power of attorney	132	132
Registration of tribute agreement	132	132
Duplicate or certified copy of any other document	228	228
Duplicate or certified copy of exploration license	342	342

Source: Government of Fiji 2010

The licences apply to blocks of 6 minutes latitude by 6 minutes longitude (Government of Fiji 2010). The size (in km²) of each block depends on the geographical location. We assume the area of one block of 6 minutes latitude by 6 minutes longitude corresponds to approximately 118.44 km², based on projection WGS84 at 16 degrees latitude. There is no information on the number of blocks per licence. Nautilus reports fees of FJ\$ 3,260 and FJ\$ 137,656 per year for two prospecting licences. However, there is no record of fees paid for the 15 remaining licences obtained by Nautilus. We calculated the value by assuming that one block of 6'x6' is approximately 118.44 km² and used the official fees for deep-sea mineral exploration. We assume that companies renew the mining licences annually and that all licences were valid at the end of 2014. We calculated the value for KORDI and Bluewater following the same approach (Table 17).

We therefore estimate that the annual value of deep-sea mining in Fiji is FJ\$ 1,551,018 (US\$ 776,480) per year.

TABLE 17 • Summary of licences for deep-sea mineral exploration in Fiji

Country	Company	Total (km ²)	No of licences	Period	FJ\$/year Current	FJ\$/year 2014	US\$/year 2014	Source
Canada	Nautilus	49	1	2006–2008	3,260	4,610	2,308	SRK Consulting 2007
Canada	Nautilus	2,412	1	2006–2008	137,656	194,676	97,460	SRK Consulting 2007
Canada	Nautilus (Sulphides)	60,370	15	2014–2016	1,184,083	1,184,083	592,782	Nautilus 2011, 2014; ECORYS 2014
South Korea	KORDI (KIOST)	27	1 (25 blocks)	2012–2014	3,260	3,469	1,737	ABC Radio Australia 2012; Atalifo et al. 2012
USA	Bluewater Metals (Neptune subsidiary)	5,012	1	2012–2014	154,283	164,180	82,193	ECORYS 2014
Subtotal		67,870				1,551,018	776,480	

Note: Each block is 6x6 minutes. Each applicant is permitted a maximum 50 blocks per application. Terms are for two years.

6.3.3.2 SAND AND AGGREGATES

In Fiji, the current price of river aggregate is nearly FJ\$ 5 per cubic metre and the annual production in 1996 was 880,000 m³, making a domestic industry with a value of FJ\$ 4–4.5 million per year. Interestingly, production tripled from 1994 to 1996; the possible environmental impacts of this growth need to be considered (Howorth 1997).

A local study in Lami on options for climate change adaptation sheds some light on the possible proxy value for coral extraction. The study stated that one of the direct benefits of coral reefs was extraction of coral for use in septic tank treatment systems. Based on local area information, the returns from coral extraction were estimated as FJ\$ 73 per week with a return of FJ\$ 10.40 per day (Rao et al. 2013). The coral reef area of Lami town was determined to be about 1,387 ha through use of spatial data analysis. Within this area, the study estimated ten harvesters selling reef products for 40 to 50 days per year with an estimated value of FJ\$ 5,214. The study further looked at least cost options for adaptation to climate change among which included replanting mangroves, building a sea wall and reduction of coral extraction. The study considered a ten year scenario with 3% *discount rate* to compare the various costs for adaptation. The cost of replanting mangroves was estimated at FJ\$ 1,781,000; building a sea wall was FJ\$ 12,377,000; and the cost of reducing coral extraction was FJ\$ 44,000 (Rao et al. 2013).

We assume the price for aggregates is FJ\$ 5 per cubic meter and consider the reported 300,000 m³ by Shi (2014) to calculate the total value for aggregates in Fiji as FJ\$ 1.5 million per year.

6.3.4 UNCERTAINTY

Information on coastal mining activities is scant; there is a high degree of uncertainty when the real rates of extraction and values generated are unknown. Scientific research on deep-sea mining and exploration is also limited. This also creates a high degree of uncertainty in determining the benefits and costs associated with mining activities which are mostly extraction of non-renewable resources.

6.3.5 SUSTAINABILITY

Since mining involves the extraction of a non-renewable resource, it should be managed using a precautionary approach and, technically, cannot be considered to be sustainable. Given the limited scientific knowledge and demand for high technology in exploring and mining the deep-sea areas, marine-based mineral extraction should be treated with caution. Such activities could potentially unleash a new set of problems such as irreversible changes to the fragile deep-sea

Pacific Island environments including potential loss of fisheries resources.

There is increasing interest in and concerns about the potential environmental impacts of deep-sea mineral exploration and exploitation. The world's first licence to operate a deep-sea mine was granted in Papua New Guinea (PNG) to Nautilus Minerals, a Canadian company (The Ocean Foundation 2014). The Ocean Foundation has raised concerns about environmental impacts of deep-sea mining and the way the environmental impact assessment was done. The experience in PNG is being watched carefully by companies interested in seabed mining or oil and gas in the Pacific region.

6.3.6 DISTRIBUTION

In coastal areas, localised mining of sand and coral directly benefits those involved in such activities. If there is consent from the resource custodians, they are also likely to benefit from the royalties or *resource rent*. There is no set price, thus arrangements are often done by mutual agreement at the local level with little government intervention.

Potential mining in offshore areas will often require joint venture arrangements among private companies or between private companies and the government. Thus, the beneficiaries will depend on the business arrangements forged between the foreign country partners and local interests. An important factor that must be incorporated very early in such arrangements is clear and transparent decision-making among all stakeholders addressing inter- and intra-generational equity and access benefit-sharing.

6.4 TOURISM AND RECREATION

6.4.1 IDENTIFY

Marine and coastal ecosystems in Fiji attract both local and international visitors. Tourism is a major contributor to the economy and presents an opportunity for poverty alleviation and positive income (re-)distribution. Fiji's coral reefs, coastlines, sparkling blue waters, sandy beaches and shoreline mangrove forests are perceived to offer beautiful views and spaces for leisure.

Domestic tourism in Fiji is widespread but on a small scale. Local people engage in limited recreational and tourism activities. People enjoy rights of entry to beach areas and very few beaches have entry fees.

International tourism is the tourist activities that foreign visitors undertake in Fiji. Visitors may have deliberately travelled for holidays or simply to enjoy part of their time in Fiji engaging in leisure activities. Therefore, every foreign visitor is assumed to be a potential tourist, at least for part of their stay. International tourism is mostly resort-based and faces the challenge of integrating with local communities. International tourism generates additional (export) *revenues* for the country.

The Tourism Development Plan 2007–2016 emphasises sustainable tourism, and one way of achieving sustainability would be by increasing the share of community benefits from tourism, for example through local partnership with tourism operators (Scheyvens and Russel 2010).

Tourism is a fast growing economic sector that contributes to economic growth of the country. In fact, at least one study has demonstrated that the number of visitors can explain macroeconomic variation and economic growth (Narayan et al. 2013).

Tourism in Fiji faces issues related to *revenue* capture and land use conflicts (Levett and McNally 2003). An important share of *revenues* from tourism leaks out of the country, due to *revenue* expatriation by foreign-owned hotels and tourism operators. A high level of imported goods (like imported food, drinks, and other inputs) that resorts and hotels provide to tourists implies that a further share of those tourism *revenues* leaves the country. Local food and other goods are sometimes not to a standard required by resorts and hotels. One way to minimise this is by incorporating and adopting food production technology in rural local communities. Another issue reported by Levett and McNally (2003) is conflict between tourist activities and fishing activity by locals on traditional fishing grounds. Waters are owned by the State, which issues permits for tourist activity. However, the villagers may also have customary use rights over the same marine area. For example, in Tavarua Island, Solevu in Malolo and Nabila in Viti Levu, villagers have frequently complained to the authorities and requested compensation for disturbance to their fishing grounds due to international tourism (Levett and McNally 2003).

6.4.1.1 TYPES OF TOURISM IN FIJI

Tourism in Fiji is primarily oriented to the sea, beach and reef and, secondarily, to other special interest tourism. Apart from the usual marine and coastal attractions, marine ecotourism has gained interest since 1998, for example, when kayaks were introduced to Fiji. Independent of the type of tourism, the health of reefs plays a crucial role in attracting tourists. Currently, the major concern with tourism industry development in Fiji is that tourism may cause serious environmental degradation, particularly on coral reefs (Levett and McNally 2003).

1. Sea and reef-based tourism. The main tourist attractions are beaches and coral reefs. The beauty of tourist destinations and Fiji's climate attract beach and sun tourists that want to enjoy the beach but also the seascape, snorkelling and diving. Major water (and sport) activities in Fiji are:

- Diving — there are 13 different types of dives offered by tourism and water sport operators in Fiji. According to water sport operators, the most popular dives are shark dives, dive courses and scuba diving.
- Game fishing — this activity peaks in August as that month is considered the game fishing month. Tourists often hire charter boats from water sport operators or bring their super yachts.
- Cruising — tourists arrive in yachts, super yachts or on cruise liners.

Other small but popular activities are: swimming in the sea, jet-skiing, jet-ski safaris, surfing, wind surfing, parasailing, water skiing, snorkelling and stand-up paddling.

2. Rivers. This kind of tourism promotes sustainable tourism with the participation of local villagers. Ecotourism and rivers provide economic alternatives for rural villagers that live far from the coast. There is an ecotourism organisation, Rivers Fiji, that has established Fiji's first conservation lease arrangement (Rivers Fiji 2014). They have implemented a sustainable management plan that involves local villagers in ecotourism on Fiji rivers.

6.4.2 QUANTIFY

In 2013 there were 657,706 international visitors to Fiji (Fiji Bureau of Statistics 2014a). From that total, some 483,830 (73.56 %) people declared that holidays were the primary purpose of their visit, 35,034 (5.33 %) arrived for business or a conference, and 56,794 (8.64%) were visiting friends and/or relatives. We assume that people visiting for business, conferences and relatives or friends are likely to spend part of their stay visiting places of tourist interest. International visitors stay on average 9.5 days. The average length of stay by purpose of visit was 8.8 for business/conferences, 20.5 days for visiting friends or relatives and 1 day for cruise ships. From the total 657,706 visitors, 109,543 (16.66%) were cruise passengers (Fiji Bureau of Statistics 2014a).

We assume that most of tourism in Fiji is motivated by beach and sun holidays. For example, according to Verdone and Seidl (2012), in 2009 approximately 70% of tourists spent their time in two provinces, Ba and Nadroga, which contain the Coral Coast, Denarau Island and the Mamanuca and Yasawa island groups. They reported that more than 75% of surveyed tourists participated in a marine-related activity: around 75% went swimming; 60% went beach-walking, snorkelling or lying on the beach; 25% went canoeing / kayaking; and 10% went scuba diving.

The stock of available rooms in Fiji was 10,197 with a total of 23,843 beds in 2013. The annual room night capacity was 3,689,145 and annual bed-night capacity was 8,666,654⁹. In 2013, 1,804,203 room nights were sold (48.8% occupancy) and 3,884,521 bed-nights (44.6% occupancy). Some 3,172,156 (81.66%) of the bed occupancy count were overseas guests and 712,365 (18.34%) were local guests. Australians comprised 57.06% of international visitors, 12.99% came from New Zealand, 7.33% from the USA, and 7.0% from Europe (3.9% from Europe and 3.1% from U.K.). The total turnover of all hotels in 2013 was FJ\$ 847,142,000 (US\$ 424,101,126) from which 55.5% corresponded to accommodation costs, 23.0% was food and 9.4% was bar and liquor (Fiji Bureau of Statistics 2014a).

Travel and tourism generated 43,000 direct jobs in 2013 (12.4% of total employment). This included employment by hotels, travel agents, airlines and other passenger transportation services (WTTC 2014). The total contribution of tourism to employment (including wider effects from investment, supply chain and induced income impacts) was 116,500 jobs in 2013 (33.5% of total employment) (WTTC 2014).

9 Room night and bed night are obtained by multiplying the available days in one year by the number of rooms or beds, approximately 363 days/year.

6.4.3 VALUE

Total earning from tourism was FJ\$ 1,383.4 million (US\$ 692.56 million) in 2012 (in 2014 dollars) and FJ\$ 1,356.4 million (US\$ 679.1 million) in 2013 (in 2014 dollars). In 2013, visitors for business and conferences resulted in FJ\$ 71.41 million (US\$ 35.75 million) or 5.26% of total earnings; visiting friends and relatives made up FJ\$ 76.97 million (US\$ 38.53 million) or 5.67% of the total; and holidays accounted for FJ\$ 1,097.84 million (US\$ 549.6 million) or 80.94% of total earnings from tourism. According to WTTC (2014), the total contribution of travel and tourism (including wider effects) was FJ\$ 2,927 million (US\$ 1,466 million) in prices of 2014 (37.1% of GDP), which is about double the direct contribution to GDP.

Based on Verdone and Seidl (2012), anecdotal observation, marketing and reputation, we assume that coastal and marine resources are the primary attractors of tourists to Fiji. Therefore, earnings for holidays of FJ\$ 1,097.84 million (US\$ 549.6 million), plus an arbitrary 30% of FJ\$ 71.41 million (US\$ 35.75 million) which corresponds to earnings from visitors for business and conferences, plus 30% of FJ\$ 76.97 million (US\$ 38.53 million) which corresponds to earnings from visitors to friends and relatives, gives total earning attributable to tourism as FJ\$ 1,145.82 (US\$ 573.63) million (82.83%) in 2013 (in 2014 dollars).

If we assume that international tourists' decisions to visit Fiji is influenced by a weighting of 80% by the coral reefs, lagoons and near shore waters and 20% by coastal resources such as mangroves and beaches, we then can obtain unit values for these coastal and marine resources per year. Fiji has 6,704 km² of coral reefs and near shore waters and 38,500 ha mangroves (equivalent to approximately 1,130 km of coastline). Assuming that the first kilometre inland from the coast is relevant for this analysis, there is 1,130 km² of coastal land. From these assumptions, we can derive with a recreational (tourism) unit value per respective resource (Table 18).

TABLE 18 • Value of tourism in Fiji

Ecosystem	Area	Unit value		Total value (million)	
		FJ\$/ha/yr	US\$/ha/yr	FJ\$/year	US\$/year
Coral reefs and lagoon	6,704 km ²	1,367.3	684.52	916.66	458.9
Mangroves	38,500 ha	5,952.3	2,979.89	229.2	114.7
Coast	1,130 km	202,800.8 ^a	101,527.3 ^a	b	b
Coastal land	1,130 km ²	2,028.0	1,015.27	b	b
Fiji land area	18,274 km ²	627.02	313.90	b	b
Total tourism				1,145.8	573.6

^a In \$ per km per year.

^b Totals for coral reefs and lagoon and for mangroves encompass the values ascribed to coasts and coastal lands.

The total *revenue* of FJ\$ 1,145.82 (US\$ 573.63) million is from 483,830 visitors for holidays, plus an assumption of 30% of 35,034 visitors for business or conference, plus an assumption of 30% of 56,794 visitors for friends and/or relatives. This leads to an estimate of 511,378 visitors. Given the total revenue, we estimate FJ\$ 2,240.65 (US\$ 1,121.70) per visitor per visit. This value is higher than that reported by Brander et al. (2007), who carried out a meta-analysis of 52 tourism/recreation valuations of coral reefs. They noted that the value of tourism and recreation associated with coral reefs in Southeast Asia and Australia was very similar, at about US\$ 300 per visitor per visit (2000 prices) (US\$ 493.70 in 2014 dollars). For Fiji, the total for coral reefs would be FJ\$ 1,792.50/visitor (US\$ 897.40 in 2014 dollars) (FJ\$ 916.66 million (US\$ 458.90 million) divided by 511,378 visitors). According to Brander et al. (2006), an overall value for all countries came to US\$ 184 per visitor per visit (US\$ 302.8 in 2014 dollars), although the median was US\$ 17 (US\$ 28 in 2014 dollars), indicating a highly skewed distribution. The differences between the valuations may lie in the fact that Brander et al. (2006, 2007) used net *revenue* plus *consumer surplus*, whereas we used gross values. In addition, we have assumed that tourists would not come to Fiji if not for the marine ecosystems and so have ascribed 100% of their expenditure towards the value of tourism; Brander et al. (2006, 2007) estimated that only a portion of the reason for the visits were due to marine ecosystems.

Shark-diving in Fiji has been estimated to attract about 10% of visitors. The total contribution from shark-diving to the economy of Fiji was estimated to be US\$ 42.2 million in 2010 (composed of *revenues* generated by the industry plus departure taxes paid by shark-divers to the government) (Vianna et al. 2011).

Data on the value of domestic tourism are difficult to find. Anecdotal information obtained from visiting different beaches along Pacific Harbour reveal that privately owned beaches require access or entrance fees. For instance, Yatu Lau private beach has an entrance fee of FJ\$ 5/person, while Northland beach charges FJ\$ 5 for motor vehicles, FJ\$ 15 for minivans and FJ\$ 80 for buses.

Tourism in Fiji is largely oriented to foreign visitors and not much attention has been given to local visitors, in terms of data collection and research. To our knowledge there are no survey-based studies describing local tourism preferences.

6.4.4 UNCERTAINTY

We rely heavily on official data released by the Fiji Bureau of Statistics. Information on visitors is obtained from declarations made by visitors to the Fiji Revenue and Customs Authority. Also, the impact of tourism in the economy, as a sector that adds value to the GDP, is an aggregate value that relies on assumptions. The lack of data does not allow a more accurate estimate of the value of tourism. Clearly, survey-based and statistically representative data should be collected to establish the perceptions of value that tourists, including local tourists, have for destinations and activities of interest and for associated natural resources.

6.4.5 SUSTAINABILITY

Tourism is a fast growing economic sector in Fiji. The challenge in the face of this fast growth is to maintain the state of the natural resources on which tourism relies, such as coral reefs. In fact, the Tourism Development Plan 2007–2016 strongly emphasises sustainable tourism. In order to achieve sustainable tourism, issues related to social as well as environmental aspects of tourism must be addressed (Ryan 2002). In some cases, environmental sustainability may not be sufficient as an objective (Ryan 2002). Ryan (2002) proposes that managers of tourism operations should be looking to add value to the environment, communities, entrepreneurs and tourists on which they rely. Narayan (2000) emphasises that promoting small-scale village-based tourism would provide opportunity to rural Fijians to participate in the cash economy.

Another issue that must be addressed is pollution and overuse. Tourism development is causing serious environmental degradation on coral reefs and other coastal ecosystems, many of them on the verge of irreversible environmental damage (Levett and McNally 2003). Anecdotal observations made at the public beaches along the Coral Coast showed a prevalence of improper waste disposal and extraction of sand on beaches. Nadi and Sigatoka are other hot spots for domestic tourism and these places use access fees to ensure some degree of sustainability.

6.4.6 DISTRIBUTION

An important share of *revenues* from tourism leaks out of the country, due to the large number of foreign-owned resorts and hotels which repatriate their *profits* (Narayan and Prasad 2003). In addition, a major share of food and drink that is served to tourists is imported (Narayan and Prasad 2003). Resorts and hotels demand food and other goods that cannot always be supplied by local production, often due to quality issues (Scheyvens and Russell 2010). A more equitable relationship between local communities and tourism operators could be created by introducing new cropping techniques that would allow them to locally supply quality goods. In this way, more of the tourism *revenue* could be retained locally. A report from FAO (2011) stated concerns about how local production could supply the quality and quantities required by the tourism industry. They advised the implementation of a kind of farmers association which might be able to supply higher volume orders, support quality control and provide delivery and credit services. Another study on the horticultural chain in Fiji suggested that quality was the most important factor affecting farmers' ability to market directly to hotels (Salvioni 2007). Ethnicity, distance from the markets and transportation were also relevant issues (Salvioni 2007).

A challenge for the tourism industry is to find ways to distribute benefits (Levett and McNally 2003). One source of income for local people may be land leasing agreements that the tourism developer and the TLTB must agree on. The TLTB represents the landowners. According to TRIP Consultants (2013), TLTB had 256 leases in its tourism portfolio, with an associated income in rents of FJ\$ 5.8 million per year. Another means to assure the equitable distribution of *revenues* from tourism is through the labour market. The tourism sector created about 43,000 direct jobs, which, added to indirect jobs, gave a total estimate of 116,500 jobs in tourism in 2013 (WTTC 2014).

Other measures that could help share *revenues* from tourism with local communities include having locals fill job vacancies, supporting capacity-building for workers and promoting the production of high quality goods (foods, drinks and other goods) to supply hotels and resorts.

6.5 COASTAL PROTECTION

This section on coastal protection was summarised from Pascal (2015), a report exploring the coastal protection ecosystem service in all five MACBIO countries and prepared for the MACBIO project. For more details on the methods or results, refer to Pascal (2015).

6.5.1 IDENTIFY

Coastal protection is a concept that includes different roles that ecosystems can play in protecting coastal areas. The two main roles identified and described here are:

- Prevention of erosion, sediment provision and/or accretion
- Mitigation of storm surges.

These two forms of coastal protection differ in their impacts. The first provides long-term protection against the wearing away of land and removal and deposition of sediments (erosion, accretion). The second offers short-term protection against coastal floods and storm surges. The short-term protection happens episodically, and the damage avoided is clearly identifiable (damaged buildings, roads, crops), while the effects of long-term protection are more diffuse over time.



Coastal protection, e.g. from coral reefs, provides a valuable benefit to Fiji.

6.5.1.1 EROSION PREVENTION AND SEDIMENT PROVISION

Coastal ecosystems in Fiji play an important role in stabilisation of shorelines. The increase of human density along coasts and the resultant increasing pressures on coastal ecosystems lead to a paradox: an increase in the need to stabilise shorelines, but a decline in natural stabilising processes.

The role of mangroves in coastal stabilisation is well known (Marchand et al. 2011; Bell and Lovelock 2013). Sediment processes protect coastal soil from erosion and permit, in some cases, reinforcement of shoreline materials. In the same way, seagrasses form extensive meadows in the coastal areas they colonise. Their roots and rhizomes fix the material in which they grow, and their leaves slow currents, thus enhancing the stability of their sedimentary substrates. This action dissipates wave energy (up to 40% of erosive energy when seagrasses are dense; Barbier et al. 2011) and also increases the rate of sedimentation (Pearson 2001). As such, seagrass beds effectively contribute to protection against waves and limit coastal erosion.

In addition, reefs are known to participate in beach formation, even though the processes involved are not yet well described (Pérez-Maqueo et al. 2007). Beach formation occurs with accumulation of sediments from various origins (marine or alluvial), a phenomenon known as sedimentation. Coastlines near coral reefs receive sediments from this ecosystem in the form of small dead coral particles. Accumulation on the coastline of those sediments is the source of beach formation. Sedimentary accretion also maintains and nourishes beaches, in opposition to natural or anthropogenic erosion (Huang et al. 2007).

Fiji has various levels of protection against erosion due to the location and quantity of several marine and coastal ecosystems. The scope of this study was to identify all ecosystem services at a national scale and, where possible, quantify and value those with readily available data. Many authors agree that assessment of erosion prevention and sediment provision is a data-demanding exercise and requires a fine resolution of analysis (e.g. Lugo-Fernandez et al. 1998; Penning-Rowsell et al. 2003; Van Der Meulen et al. 2004). For example, on a 1 km scale, neighbouring beaches can suffer both erosion and sand accretion depending on geomorphological and biological factors (Brander et al. 2004). Although it has not been possible to precisely quantify the ecosystem service of protection against erosion, three major aspects have been identified for Fiji:

1. stabilisation of shorelines, critical in high human density sites (e.g. Suva)
2. beach formation and stabilisation, important in tourist areas (e.g. Coral Coast, Viti Levu, Savusavu, Vanua Levu)
3. atoll formation and stabilisation, very important for atoll countries.

Fiji has the third largest mangrove area in the Pacific Island region, after Papua New Guinea and the Solomon Islands. The mangrove area was estimated from a forest cover map prepared by the Ministry of Forests, based on a 1985 survey, with mangroves distinguished using the Fiji Forest Inventory carried out in 1966. This gave a total mangrove area for Fiji of 517 km². Around 90% of Fijian mangroves are located in Viti Levu and Vanua Levu where there is greatest human coastal density. Mangrove ecosystems also contribute to the stabilisation of beach sands, which is a major asset for tourism. For example, mangroves located on the south coast of Viti Levu may have a role in stabilisation of the beaches of the Coral Coast, a major tourist destination.

The role of coral reefs in processes involved in erosion protection (sedimentation and accretion) is less well understood than the role of mangroves. Furthermore, although some natural processes involved in erosion protection are well described, it is difficult to precisely quantify and estimate the *economic value* of such processes.

6.5.1.2 STORM SURGE MITIGATION

This study focuses mainly on the value of storm surge mitigation by coral reefs, which is one of the most important aspects of coastal protection provided by marine ecosystems (Laurens et al. 2013). As a point of reference, average annual direct loss caused by tropical cyclones floods in 15 South Pacific countries was calculated to be up to US\$ 80 million (2009 prices) with 60% of the damage resulting from loss of residential buildings, 30% from loss of cash crops and 10% from damage to infrastructure (PCRAFI 2011).

Storm systems such as tropical cyclones and mid-latitude storms and their associated cold fronts are the primary causes of storm surges¹⁰. Storm surges can interact with other ocean processes such as tides and waves to further increase

¹⁰ A storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

coastal sea levels and flooding, and have maximum impact when they coincide with high tide. Breaking waves at the coast can also produce an increase in coastal sea levels, known as wave setup. Storm surges occurring at higher mean sea levels enable inundation and damaging waves to penetrate further inland, which increases flooding, erosion and damage to built infrastructure and natural ecosystems. The effect of rising mean sea levels due to climate change will be felt most profoundly during tsunamis and extreme storm conditions (CSIRO and Australian Bureau of Meteorology 2007)¹¹.

Coastal bathymetry (shape and depth of sea or ocean floor), the presence of bays and headlands and the proximity of other islands also affect the height of storm surges. Wide and gently sloping continental shelves amplify storm surges, while bays and channels can funnel and increase storm surge height.

Coral reefs, seagrass and mangroves provide protection against waves by forming barriers along the coastline. As a result, lagoons, which are protected by barrier reefs, are relatively calm areas that provide multiple ecosystem services described in other chapters (e.g. biomass production, scenic beauty). Several studies have shown that reefs act in a similar manner to breakwaters or shallow coasts (Lugo-Fernandez et al. 1998; Brander et al. 2004; Kench and Brander 2009). They impose strong constraints on the swell of the ocean, resulting in transformations of wave characteristics and a rapid attenuation of wave energy.

Waves formed by the wind store a large part of their energy at the surface, and this force can be absorbed by fringing reefs and reef crests, sometimes up to 90% at low tide (Lugo-Fernandez et al. 1998). The degree of energy absorption is highly variable and depends on the type of reef, the depth and the waves (Kench and Brander 2009). The role of coral reefs and mangroves in coastal protection is difficult to isolate from other variables and, in fact, a combination of factors impact on the level of protection provided. The primary factors influencing attenuation of wave energy are:

1. bathymetry (shape and depth of sea or ocean floor)
2. geomorphology (soil origin and composition)
3. topography (coastal and inland surface shape, as well as shoreline indentations)
4. biological cover (presence of other ecosystems in the coastal area) (Burke 2004).

Few studies have focused on isolating the specific role of coral reefs within this combination of factors (Badola and Hussain 2005). In addition to the complexity of quantifying the specific contribution of coral reefs to coastal protection, an analysis by Barbier et al. (2008) found that the relationship between reef area and absorption of wave energy was nonlinear. Similar nonlinear effects have been measured for the effect of mangroves on wave height. Waves of 1.1 m in the sea are reduced to 0.91 m in the mangrove forest if the forest has an inland extension of 100 m. The wave continues to decline, at a slower rate, for each additional 100 m of mangrove extension inland. For a forest extending 1000 m inland, the waves would be reduced to a negligible 0.12 m¹² (Barbier et al. 2008).

6.5.2 QUANTIFY

6.5.2.1 COASTAL PROTECTION INDEX

Two methods can be used to assess the role of coral reefs¹³ in coastal protection: methods based on biological properties of reefs, and methods based on physical and mechanical properties of the reefs. Due to the large quantity of information required for the biological method, and the requirement of small study areas, we chose to use a physical and mechanical model for our evaluation. One of the main limitations of such models is that we were not able to assess the true relationship between coral mortality and its role in loss of coastal protection service.

The model used for this study scores coastal stability based on seven physical characteristics (Table 19). These physical characteristics were given a score between 1 and 5 and the average was calculated to produce a unique index value for each segment of shoreline: the coastal protection index.

11 A tsunami differs from wind-generated wave in that the former is much larger and its energy is distributed throughout the water column. The impact of bathymetry in wave attenuation is even more important in case of tsunami waves; due to this vertical continue distribution of energy throughout the column water rather than the surface distribution of storm surge waves.

12 In addition, some studies have shown that the extent of reefs or mangrove may not be the main factor influencing the reduction of damage on the coast from of tsunamis (Done et al. 1996; Greer Consulting Services 2007; Pérez-Maqueo et al. 2007).

13 Three major ecosystems contribute to coastal protection: coral reefs, mangroves and seagrasses. Nonetheless methodologies to assess *economic impacts* of mangroves and seagrass in terms of coastal protection are not yet consolidated (Huang et al. 2007; Pérez-Maqueo et al. 2007; IFRECOR 2011; Pascal 2013), the specific role of those ecosystems is not monetarised in the present study; they are only used in the coastal protection index as one of the main factors contributing to coastal protection.

TABLE 19 • Calculation of the coastal protection index based on characteristics of the coastline

Factor	Score				
	Very strong	Strong	Medium	Low	Null
	5	4	3	2	1
Geomorphology	Rocky shore	Mix of rocks/ sediments/ mangroves	Mangroves	Sediments	Beaches
Coastal exposure	Protected bay	Semi-protected bays	Artificial reefs	Low protected bay or coast	No protection
Reef morphology, area and distance to coastal physical structure	Continuous barrier (> 80%) close to the coast (< 1 km)	Continuous barrier (> 50%), patch reef, close to the reef	Fringing reef (width > 100 m)	Coral formation discontinuous	No reef
Inner slope, crest width	Very favourable conditions (gentle slope, large crest width)	Favourable conditions (slope, large crest width)	Favourable conditions (at least one condition: slope, crest width)	Reduced favourable conditions (strong slope, reduced crest width)	None
Platform slope	6–10%	2.5–6%	1.1–2.5%	0.4–1.1%	< 0.4%
Mean depth (< 1 km from the shoreline)	< 2 m	< 5 m	> 5 m	< 10 m	< 30 m
Other ecosystems	Mangroves and seagrasses > 75% coastline	Mangroves and seagrasses > 50% coastline	Mangroves and seagrasses > 25% coastline	Mangroves and seagrasses < 25% coastline	None

Two main GIS databases were used for data related to reefs (i.e. type of reefs, area and distance to the coast): PCRAFI and Reefbase data.

Coastal protection on the two largest islands (Viti Levu and Vanua Levu) was valued. Each island was divided into two areas, north and south (four segments in total). This division was made as a result of the location and morphology of coral reefs around each island (Figure 9). The north coasts of the two islands are protected by the Cakaulevu Barrier Reef, while the two south coasts are mainly protected by fringing reefs. Fiji's largest continuous fringing reef (over 100 km) is located on the southwest coast of Viti Levu (Chin et al. 2011), while the fringing reef is discontinuous on the southeast coast (PCRAFI GIS data).



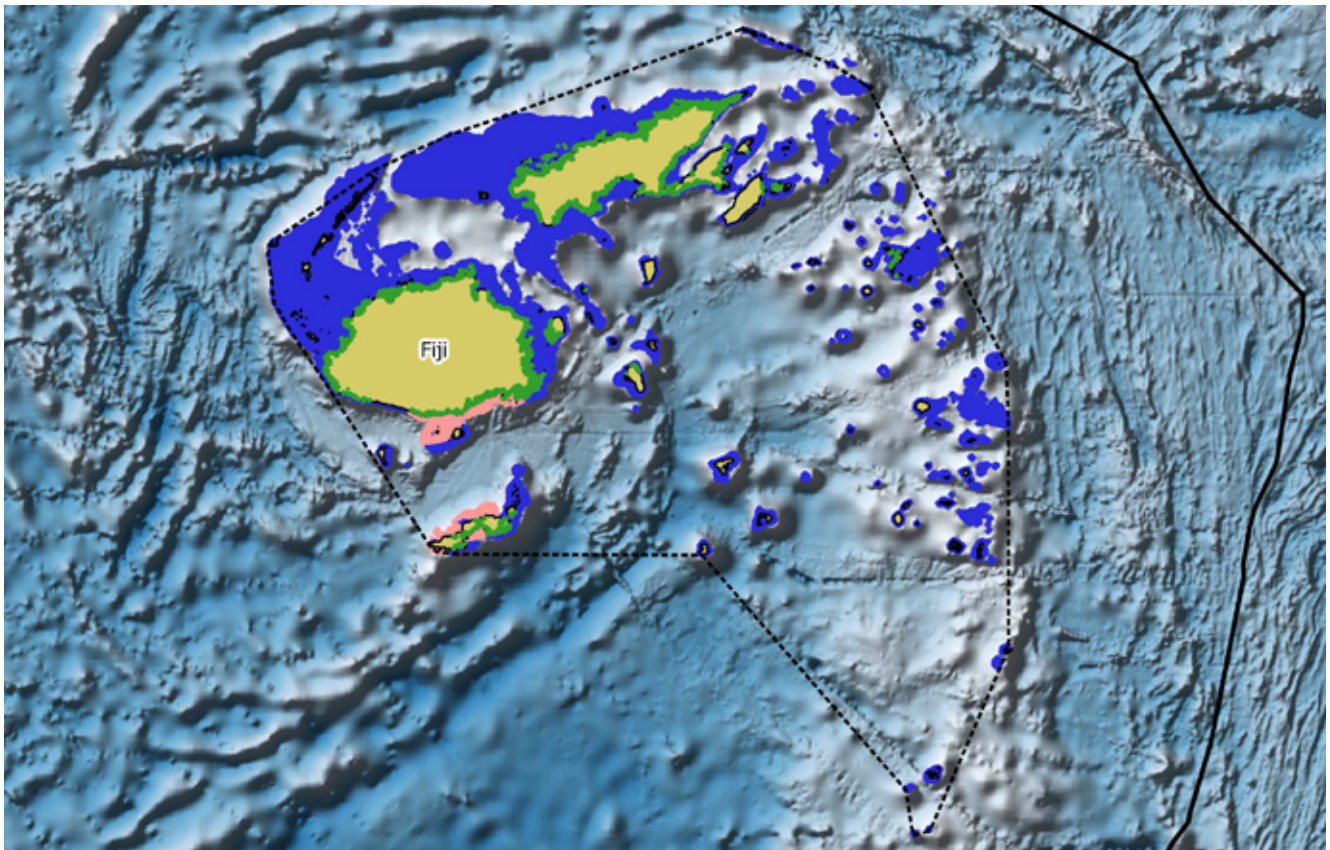


FIGURE 10 • Map of Fiji's Mangroves (green), Seegrass (pink) and reefs (blue)

Geomorphology: 90% of Fiji's mangroves are located on Viti Levu and Vanua Levu. Although the north coasts of both islands are primarily rocky, the presence of mangroves at various densities around the perimeter of the islands means the score for geomorphology is medium (3) for all areas.

Coastal exposure: The south coast of Vanua Levu has four bays (from west to east: Bua Bay, Wainunu Bay, Savusavu Bay, and the largest, Natewa bay). The presence of bays protects this shoreline against floods (score: very strong, 5). The north coast of Vanua Levu and the shoreline of Viti Levu are more linear (scores: low protected bay or coast, 2), and the south coast of Viti Levu is the most linear shoreline (no protection, score 1).

Reef morphology, area and distance to the coast: The south coasts of the two islands are less protected by reefs than those on the north coasts. On Viti Levu, a continuous barrier reef creates a lagoon to the north of the island (score: very strong, 5), while the reefs on the south coast are closer to the coast and less developed (score: medium, 3). In Vanua Levu, the reefs are more developed along the north coast (> 50%, score: strong, 4), while in the south there are less developed fringing reefs (score: medium, 3)

Inner slope, crest width: The crest is relatively narrow (10–25 m), while the inner slope is medium or absent. In every study area, scores for this factor were medium, 3.

Platform slope: The deep ocean is near the shoreline of the islands, so the platform presents an important slope (score: strong, 4 in all areas).

Main depth (1 km from the shoreline): The deep ocean is near the shoreline on both islands, so the main depth is greater than 30 metres less than 1 km from the coast, except in the North of Viti Levu, where the presence of the lagoon reduces the main average depth. Scores for this factor are null (1) everywhere except for the north coast of Viti Levu, where it is medium (3).

Other ecosystems: According to the 1986 map from Fiji Mangrove Management Committee and our study areas division, 15 419 ha of mangroves are located along the north coast of Viti Levu and 7 872 ha are on the south coast. On Vanua Levu, 24 781 ha of mangroves are located along the north coast and 6 357 ha are on the south coast. More precisely, the largest areas are on the southeast (Rewa River delta) and northwest (Ba and Nadi Rivers delta) shorelines

of Viti Levu, and the northern shore of Vanua Levu (especially around Labasa River delta) (Richmond and Ackermann 1975). One of the main issues regarding mangrove health on both islands is the proximity between the most inhabited cities and the most developed mangrove locations (Figure 10), urban expansion near deltas leading to a decrease of natural surface colonised by mangroves.

Scores for the factor other ecosystems are medium (3) for the south coast of Vanua Levu, and strong (4) for the three other sections. If we were to use smaller study areas, the southeast coast of Viti Levu would have a score of very strong (5) for other ecosystems, while the rest of the south coast would have had a score of medium (3). Similarly, the northwest shoreline of Viti Levu and the northeast of Vanua Levu would have scores of very strong (5) for other ecosystems, while the rest of the north coast of both islands would be medium (3). However, it was not possible to take into account all spatial variations of each factor in the determination of the coastal protection index, so averages for larger areas are chosen to express the degree of protection provided by mangroves.

The coastal protection index for the four study areas is summarised in Table 20.

TABLE 20 • Coastal protection index for four study areas on Viti Levu and Vanua Levu

Coastal protection factor	South coast Viti Levu	North coast Viti Levu	South coast Vanua Levu	North coast Vanua Levu
Geomorphology	3	3	3	3
Coastal exposure	1	2	5	2
Reef morphology, area and distance to the coast	3	5	3	4
Inner slope, crest width	3	3	3	3
Platform slope	4	4	4	4
Main depth (1 km from the coast)	1	3	1	1
Other ecosystems	4	4	3	4
Average	3	4	4	3

6.5.2.2 MAIN NOTABLE ASSETS AT RISK

We assessed the number, type and location of residential buildings and hotels at risk from coastal flooding and tsunamis. No robust information related to other construction works, such as public buildings and infrastructure (e.g. roads, bridges and airports) was available. Agricultural crops were also not included in the study, due to the absence of intensive crop production in the areas at risk. Data on indirect tangible damage (e.g. loss of tourism revenue, emergency costs, traffic disruption) were also unavailable.

Main cities:

On Viti Levu, the three most inhabited cities are Suva in the south-east of the island near the Rewa River delta (capital city, 74 500 inhabitants), Lautoka in the north-west, near the Ba River delta (52 000 inhabitants) and Nadi, south of Lautoka near the Nadi River delta (40 000 inhabitants).

In Vanua Levu, the most inhabited city is Labasa in the north-east (27 900 inhabitants).

Another important city is Savusavu (3 300 inhabitants), located on the south coast. This city is called the ‘hidden paradise of Fiji’, and it is one of the tourist centres of the country, with most of the hotels of the island located there.

Tourism: The principal tourist areas on Vanua Levu and Viti Levu are identified based on the location of luxury hotels.

In Vanua Levu, there are nine hotels with ratings greater than two stars (Table 21), as well as six secondary hotels and 19 other vacation residences (e.g. bed-and-breakfast, cottages). Among the nine hotels, only two are located in the north; of those two, one is located outside the area at risk of coastal flooding (Emaho Sekawa Resort in Labasa), while the other offers only a few units (the 5-star Nukubati private island resort, with seven rooms). The seven other hotels are all located in or near Savusavu, on the coast.

On Viti Levu, there are 59 luxury hotels, 25 secondary hotels, and around a hundred other vacation residences (Table 21). There are three main tourist areas on the island where most of the luxury hotels are concentrated:

- the capital Suva, with city hotels
- the Coral Coast, an 80 km stretch of beaches and bays along the Ocean Road between Nadi and Suva
- Western Nadi, with two major concentrations of hotels at Denarau Island and the international airport of Nadi (all hotels in this latter area are located out of areas at risk).

The majority of hotels on Viti Levu is located on the south coast of the island, on a land strip between Suva in the east and Nadi in the west.

TABLE 21 • Hotels in Viti Levu and Vanua Levu

Type of vacation residence	Viti Levu	Vanua Levu
5-star hotel	8	4
4-star hotel	14	2
3-star hotel	24	3
2-star hotel	6	0
Other hotel	25	6
Other type of tourist accommodation	98	19
TOTAL	175	34

6.5.3 VALUE

The method used to value the service of protection against storm damage by coral reefs¹⁴ is the *avoided damage cost method*. First the assets protected are identified and quantified. Then, the *ecosystem contribution factor* for coral reef and associated systems is applied. Finally, the ecosystem service is valued in terms of the cost of damage avoided. One of the main challenges of this method is that coastal protection against waves is a complex process, incorporating many factors such as geomorphology of the coast and the presence of other ecosystems. The identification of the contributing role of each of the different factors is a challenging task and is outside the scope of this study. For more details on methods, see Pascal (2015).

Similar methodologies used to value this ecosystem service have been tested on Caribbean (Burke 2004) and New Caledonian reefs (Pascal 2010).

Total avoided damage and annual avoided damage (due to the presence of reefs) of human assets are presented for the four areas at risk first (disaggregated results: Tables 22–25), then aggregated for the two islands (aggregated results: Table 26).

14 Methods to assess economic value of mangroves and seagrass for coastal protection are not yet implemented (Huang et al. 2007; Pérez-Maqueo et al. 2007; IFRECOR 2011; Pascal 2014) and the specific role of those ecosystems was used mainly for calculation of the coastal protection index as one of the main factors contributing to coastal protection. Their role has not been monetised in this study.

TABLE 22 • Costs of damage avoided due to the presence of coral reefs, south coast of Viti Levu

Relative coastal protection index	0.24	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damage	
	Extreme climatic event probability (100 years)	Min	Max			Minimum	Maximum	Minimum	Maximum
Houses	0.23	1428	2380	houses	US\$	9,270,383	15,450,638	2,132,188	3,553,647
					FJ\$	18,517,590	30,862,650	4,259,046	7,098,410
Luxury hotel	0.23	17	28	hotels	US\$	5,894,498	9,824,164	1,355,735	2,259,557
					FJ\$	11,774,260	19,623,767	2,708,080	4,513,466
Total	0.23				US\$	15,164,881	25,274,802	2,796,764	5,813,205
					FJ\$	30,291,850	50,486,417	5,586,536	11,611,876

TABLE 23 • Costs of damage avoided due to the presence of coral reefs, north coast of Viti Levu

Relative coastal protection index	0.40	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damage	
	Extreme climatic event probability (100 years)	Min	Max			Minimum	Maximum	Minimum	Maximum
Houses	0.23	74	123	houses	US\$	803,625	1,339,374	184,834	308,056
					FJ\$	1,605,240	2,675,400	369,205	615,342
Luxury hotel	0.23	16	26	hotels	US\$	8,497,999	14,163,332	1,954,540	3,257,566
					FJ\$	16,974,753	28,291,255	3,904,193	6,506,989
Total	0.23				US\$	9,301,624	15,502,706	2,139,373	3,565,623
					FJ\$	18,579,993	30,966,655	4,273,398	7,122,331

TABLE 24 • Costs of damage avoided due to the presence of coral reefs, south coast of Vanua Levu

Relative coastal protection index	0.28	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damage	
	Extreme climatic event probability (100 years)	Min	Max			Minimum	Maximum	Minimum	Maximum
Houses	0.23	150	250	houses	US\$	1,127,534	1,879,224	259,333	432,222
					FJ\$	2,252,250	3,753,750	518,018	863,363
Luxury hotel	0.23	5	8	hotels	US\$	1,174,041	1,956,735	270,030	450,049
					FJ\$	2,345,147	3,908,578	539,384	898,973
Total	0.23				US\$	2,301,575	3,835,959	529,362	882,270
					FJ\$	4,597,397	7,662,328	1,057,401	1,762,335

TABLE 25 • Costs of damage avoided due to the presence of coral reefs, north coast of Vanua Levu

Relative coastal protection index	0.35	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damage	
		Min	Max			Minimum	Maximum	Minimum	Maximum
Extreme climatic event probability (100 years)	0.23								
Houses		129	215	houses	US\$	1,234,138	2,056,896	283,852	473,086
					FJ\$	2,465,190	4,108,650	566,994	944,990
Total					US\$	1,234,138	2,056,896	283,852	473,086
					FJ\$	2,465,190	4,108,650	566,994	944,990

TABLE 26 • Total cost of damage avoided due to the presence of coral reefs, Fiji

Relative coastal protection index	0.32 ¹⁵	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damage ¹⁶	
		Min ¹⁷	Max			Minimum	Maximum	Minimum	Maximum
Extreme climatic event probability (based on a 100 years historic)	0.23								
Houses		1781	2968	houses	US\$	12,435,680	20,726,133	2,860,206	4,767,011
					FJ\$	24,840,270	41,400,450	5,713,262	9,522,104
Luxury hotel		121,095	201,825	m ²	US\$	15,254,691	25,424,485	3,508,579	5,847,632
					FJ\$	30,471,245	50,785,409	7,008,386	11,680,644
Total					US\$	27,690,370	46,150,618	6,368,785	10,614,642
					FJ\$	55,311,515	92,185,859	12,721,649	21,202,748

The coastal protection services provided by coral reefs for hotels are a major benefit in Savusavu on Vanua Levu, and along the Coral Coast and in Nadi and Suva on Viti Levu. For Savusavu and the Coral Coast, the importance of coral reefs for tourism is double: they provide protection against storm surges during extreme climatic events; and healthy reefs attract tourists to those areas.

Coastal protection against damage to houses provided by coral reefs is a major benefit for Labasa in Vanua Levu, and for the south coast of Viti Levu from Suva to Nadi, and Lautoka in the west, the second largest city in Fiji.

15 The relative coastal protection index represents the average index of protection for the two islands. It is an average of the four coastal protection indices calculated for each segment

16 Total value of avoided damage represents all the damages occurring during an extreme climatic event; annual avoided damage is the total avoided damage multiplied by the probability of an extreme climatic event

17 Minimum and maximum values represent uncertainties. See Section 6.5.4 for more details.

6.5.4 UNCERTAINTY

This approach is exploratory. It aims to produce an overview of the quantification and valuation of coastal protection provided by coral reefs against flooding caused by cyclone-induced storm surges. Many uncertainties are present in every step of the approach. The main uncertainties are: the choice of damage functions (flood damage percentage), definition of zones at risk, the data used for GIS analysis, the database of assets and valuations of construction costs. For details, see Pascal (2015).

Our approach to defining zones at risk partly consists of counting assets at risk from satellite images, which is likely to lead to underestimates. The damage costs of flooding are therefore likely to be higher.

A standard construction cost was used across the five MACBIO countries, regardless of the type of structure and materials. Even if this cost reflects an average construction price per square metre, it is possible that it under- or overestimates the total repair cost of assets at risk.

The flood damage percentage used in the analysis came from estimates made by the US Federal Emergency Management Agency for houses in California. Houses in Fiji may suffer higher rates of damage since they are generally of lower construction quality. Again, this suggests that actual damage costs may be higher than estimated.

Minimum and maximum values are presented in Tables 22–26 to reflect these uncertainties. The minimum value was calculated multiplying the estimated total number of houses by a factor of 0.75, while the maximum value was calculated by multiplying the total number of houses by a factor of 1.25.

This analysis provides an overview of the role of coral reefs in the coastal protection of some built assets (residences and hotels) at risk of extreme climatic events. Many additional parameters must be taken into account to better understand the link between coastal habitats and coastal protection. The role of seagrasses, live coral cover and processes involved in erosion regulation, and impacts on other built infrastructure and crops also need to be explored to fully value this ecosystem service.

6.5.5 SUSTAINABILITY

Reef, mangrove, and seagrass ecosystems provide consistent coastal protection benefits, indefinitely, so long as the ecosystems remain intact. The human benefit of coastal protection derived from coastal ecosystems such as mangroves and coral reefs do not have any negative impact on the ecosystems themselves and so, in this way, this ecosystem service is sustainable. Of course, human activities may impact on these ecosystems, reducing the coastal protection service. Damage to reefs and mangroves from coastal development is an ongoing threat (Burke et al. 2008). The magnitude of the services could be increased in some instances by restoring blighted or damaged reefs, mangroves, and seagrasses.

Climate change, in particular acidification of oceans and warmer water temperatures, could impact reefs and mangroves and threaten the sustainability of this ecosystem service. Climate change may also increase the intensity and severity of storms, increasing the importance of coastal protection services but also increasing the expected damages. Cyclone Pam demonstrated in Vanuatu that the most severe storms will still cause catastrophic flooding and erosion. It is difficult to estimate how much damage would have occurred in Vanuatu if it were not for the presence of living reef and mangrove ecosystems.

6.5.6 DISTRIBUTION

The benefits of coastal protection accrue to anyone who owns or uses property along coastal areas. The beneficiaries may be nationals, expatriate residents or visitors. Protection of public infrastructure, such as wharfs, marinas and roads, benefits everyone who uses that infrastructure and could decrease the country's tax burden through avoided repair costs.

6.6 CARBON SEQUESTRATION

6.6.1 IDENTIFY

Carbon stored and sequestered by marine and coastal resources is known as 'blue carbon' (Pendleton et al. 2012; Thomas 2014). Oceans absorb and store increasing amounts of carbon dioxide (CO₂) as the concentration of carbon increases in the atmosphere. The increase of CO₂ in seawater increases its acidity (Hilmi et al. 2013) with consequences for marine ecosystems (Battle et al. 2000). Other coastal resources such as mangrove forests, seagrass beds and salt marshes can store high amounts of carbon. According to Currie and Wowk (2009), the coastal carbon sink corresponds to half of all carbon sequestered in ocean sediments overall. Clearing or degradation of such resources releases the sequestered carbon into the atmosphere (Hilmi et al. 2013).

Blue carbon is considered a cost-effective means for climate change mitigation and adaptation (Thomas 2014). Mangrove forests, seagrass beds and salt marshes are interdependent ecosystems and the state of one may affect the state of the others. Apart from carbon storage and sequestration, these ecosystems provide a series of environmental services that are important for the livelihood of human populations. We identify oceans, mangroves, tidal salt marshes and seagrass beds as potential reservoirs of carbon.

Oceans cover more than two-thirds of the Earth's surface including 1.29 million km² of ocean within the outer boundary of Fiji's EEZ. They absorb over 80% of heat added to the climate system and over 50% of anthropogenic carbon emissions (Currie and Wowk 2009). Therefore, oceans play a crucial role in climate regulation and carbon absorption. However, temperature changes and increasing atmospheric carbon have effects on the ocean's capacity to support marine ecosystems and produce food. The CO₂ dissolved in the surface layers of the oceans has an acidic effect that decreases the concentration of carbonate in the water. The lower level of carbonate adversely affects the growth of corals, crustaceans, bivalves and plankton (Currie and Wowk 2009).

Deep oceans have been seen as a potential storage location for CO₂ in two ways: by injecting and dissolving CO₂ into the water (typically below 1,000 metres depth) using a pipeline; or by depositing CO₂ on the deep seabed, below 3,000 metres (IPCC 2005). At this depth, CO₂ is denser than water and is expected to form a CO₂ lake that would delay dissolution (IPCC 2005). The cost of ocean storage (injected) is estimated to range US\$ 5–30/tonne CO₂ equivalent, including offshore transport for 100–500 km, excluding monitoring and verification (IPCC 2005). This alternate involves environmental trade-offs, given that injection of carbon in the ocean would kill ecosystems and increase the pH of oceans.



Carbon sequestration from mangroves brings benefits worth about FJ\$ 148 M each year (US\$74 M).

Mangrove forests include the formations of trees and bushes on coastal reef flats, estuarine areas and wetlands. Mangroves are often present in association with seagrasses and coral reefs. In Fiji, the most abundant species are *Rhizophora* spp., *Bruguiera* spp., and *Avicennia* spp. (Watling 1985; Agrawala et al. 2003). The main direct uses of mangroves by local communities in Fiji are related to gleaning and fishing for food and extraction of wood for fuel, building, charcoal and dye. Mangroves are also cleared for urban development or cropping. The state of conservation of mangrove forests affects the state of seagrass beds, and also coral reefs (Nunn 2000; Klein et al. 2014). For example, Nunn (2000) found evidence that mangrove clearing over the last 200 years has affected the state of coral reef ecosystems in Ovalau and Moturiki islands.

Among the most noticeable environmental services from mangroves is the stabilisation of sediments from the rivers and floods. Shrimps and fish also use them as nurseries (Dalzell et al. 1996). Agricultural activities and forest clearing in uplands can impact on mangroves by causing extra loads of soil to be delivered downstream for mangroves to filter and assimilate and, potentially, cause more intense floods due to the reduction of water retention in the catchment. Degradation or removal of mangroves can affect the state of coral reefs. For example, Dadhich and Nadaoka (2012) reported deterioration of coral reefs in response to intense anthropogenic perturbations in the river basins in north-western Viti Levu that they explained by conversion of coastal forestlands and grasslands to agricultural production. Mangrove forest clearing means that carbon stored in aerial biomass is rapidly released to the atmosphere. Carbon stored in the soils beneath the mangroves is released more slowly. The rate of release depends on the alternative use of the land. Seagrasses and salt marshes may also be affected by mangrove clearing and this may lead to release of part of their stored carbon.

In Fiji there are 38,500 ha of mangrove forests. A Mangrove Management Plan (MMP85) (Watling 1985) was used for decision-making until 1993. After then, it was rarely used by government officers and only in cases of convenience for EIA (Watling 2013). According to Watling (2013), for example, the Forests Department did not use it to assess 11 mangrove licences within the Suva-Navua or Rewa Delta, since none of them were in Wood Production Zones designated by the MMP85. Moreover, four were in Resource Reserves, three in Traditional Use Zones, two in Sewage Processing Zones and one in a Development Zone. Watling also highlighted the damage caused to mangroves from sewage disposal and from dredging in the Labasa and Rewa deltas, in spite of the guidelines for good dredging practices that are contained in the MMP85 (Watling 1985) and the additional documentation prepared by Tortell et al. (1992).

Mangrove forests have historically been cleared mainly for agricultural use, but also for residential, industrial use or tourism development. Lal (1990) reported that 4,313 ha of mangrove forests were converted in the period 1896–1986 (Table 27).

TABLE 27 • Total mangrove reclamation for various purposes, 1896–1986

Period	Agency / purpose	Purpose	Area (ha)
Pre-1920	Colonial Sugar Refining Company	Reclamation	2,334
		Infill	56
Post-1960	Government	Industrial and services	157
		Agricultural	1,321
		Agricultural excluding rehabilitation	1,159
	Private sector	Industrial	19
		Residential	31
		Tourism	557
Total 1896–1986			4,313

Source: Lal 1990

In spite of the existence of an EIA system in Fiji, the country has not demonstrated serious efforts to control and enforce environmental regulations, nor has it applied effective EIAs in projects that potentially degrade mangroves (Turnbull 2003).

Tidal salt marshes are intertidal ecosystems mainly formed by vascular flowering plants such as perennial grasses and primary producers such as macroalgae, diatoms and cyanobacteria (Murray et al. 2010). Tidal salt marshes store large amounts of carbon in deposited sediments. The main drivers of salt marsh conversion are drainage for agriculture or urban development or impoundment for salt ponds (Murray et al. 2010). Salt marshes occur in the river deltas of Fiji (Eisma 1998).

Seagrass beds are formations of underwater flowering plants found in coastal waters (Murray et al. 2010). Water quality degradation and mechanical damage are identified as drivers of seagrass loss (Murray et al. 2010). For example, in an assessment of seagrasses in Pohnpei and Ahnd Atoll in Federated States of Micronesia, sedimentation and turbidity, primarily as a result of watershed runoff and marine extraction activity, were identified as major threats in some locations (McKenzie and Rasheed 2006). Many seagrasses were found at less than three metres depth. To our knowledge there are no maps of seagrass beds in Fiji. However, there have been some biological and vegetation recognition studies and a series of meetings has been organised in Fiji by SeagrassWatch, a global, scientific, non-destructive seagrass assessment and monitoring program. Details of the plant species associated with seagrass can be found in McKenzie and Yoshida (2007, 2010), which also present lists of places surveyed for seagrass beds in Fiji. Seagrass beds have also been recognised as foraging areas for turtles and are widely recognised as critical for sea turtle conservation (McKenzie and Yoshida 2007).

6.6.2 QUANTIFY

Oceans. It is estimated that oceans have absorbed about one-third of extra carbon released to the atmosphere since the beginning of industrial era (Currie and Wowk 2009). According to Battle et al. (2000), the world’s oceans captured 2.0 ± 0.6 gigatonnes of carbon per year (GtC/year) in the form of CO₂, during 1991–1997. The world’s oceans cover an area of near 3.6×10^8 km²; Fiji has a marine area of ~ 1.29 million km². Thus, we can assume that oceans sequester 5.56 tonnes CO₂/km²/year or 0.0556 tCO₂/ha/year. Therefore Fiji’s EEZ accounts for 7,166,667 tCO₂/year of carbon sequestration.

Mangroves. Coastal ecosystems such as mangroves, marshes and seagrasses sequester 4.4–7.97 tCO₂eq/ha/year (Table 28; Murray et al. 2010). Mangroves contain the largest per-hectare carbon stocks of any ecosystem in the world and may represent three to five times the carbon stored in a typical tropical forest (Pendleton et al. 2012). This is because mangroves accumulate large amounts of organic matter in the ground, including the radicular biomass.

TABLE 28 • Carbon sequestration and carbon pools of coastal ecosystems

Habitat type	Annual carbon sequestration rate (tCO ₂ eq/ha/year)	Living biomass (tCO ₂ eq/ha/year)	Soil organic carbon (tCO ₂ eq/ha/year)
Seagrass	4.4 ± 0.95	0.4–18.3	66–1,467
Tidal marsh	7.97 ± 8.52	12–60	330–4,436
Estuarine mangroves	6.32 ± 4.8	237–563	1,060
Oceanic mangroves	6.32 ± 4.8	237–563	1,690–2,020

Source: Murray et al. 2010

In Fiji there are 38,500 ha of mangroves (Watling 2013). This area stores an average of 1,023 tCO₂eq/ha (Donato et al. 2011). To our knowledge, there are no official records of recent mangrove losses or degradation since information provided by Watling (1985). Monitoring of mangrove areas in Fiji is crucial for estimating annual carbon losses and to propose further policy instruments for reducing emissions from mangroves conversion and degradation (equivalent to REDD+ mechanism6).

Tidal salt marshes. To our knowledge there is no measurement of the area of salt marshes in Fiji. They are presumably included as part of mangroves.

Seagrasses. According to McKenzie and Yoshida (2010), seagrass meadows are rated as the third most valuable ecosystem globally (per hectare) for carbon sequestration, only exceeded by estuaries and wetlands. We are unaware of any measurement of the area of seagrass beds in Fiji.

6.6.3 VALUE

The value of carbon sequestration by oceans and coastal ecosystems has global relevance. These resources are able to sequester carbon as long as they are not damaged or destroyed. The benefit of this ecosystem function can be valued as a global social benefit. The *social cost of carbon* (SCC) is an estimate of economic damage associated with a marginal increase in carbon dioxide emissions (US\$/tCO₂/year) and also represents the value of damage avoided for a small emission reduction (i.e. the benefit of a CO₂ reduction) (US EPA 2015). We use the SCC value of the US EPA (2015) of US\$ 61/tCO₂/year (reflecting a 2.5% social *discount rate*) and rates of carbon sequestration presented by Murray et al. (2010). Using these values we calculated the global benefits of carbon sequestration by marine and coastal resources in Fiji (Table 29) Note that because the area of seagrasses and tidal marshes in Fiji are unknown, those benefits are not included.

TABLE 29 • Social benefits of CO₂ sequestration by marine and coastal ecosystems¹⁸

Habitat	Annual carbon seq. rate (tCO ₂ eq/ha/year)	Area (km ²)	Unit value		Total value	
			FJ\$/ha/yr	US\$/ha/yr	FJ\$ million/year	US\$ million/year
Ocean	0.0556	1.29 million	6.77	3.39	873.33	437.31
Seagrass	4.4	NA	536.13	268.40	NA	NA
Tidal saltmarsh	7.97	NA	971.12	486.17	NA	NA
Mangroves	6.32	385	770.08	385.52	29.65	14.84

TABLE 30 • Annualised social value of carbon sequestration plus avoided emissions of marine and coastal resources in Fiji

Ecosystem	Area (km ²)	Unit value		Total value	
		FJ\$/ha/yr	US\$/ha/yr	FJ\$ million/year	US\$ million/year
Ocean	1,290,000	6.77	3.39	873.33	437.31
Seagrass	NA	1,515.25	758.3	NA	NA
Tidal marsh	NA	2,759.94	1,381.70	NA	NA
Mangrove	385	3,835.60	1,920.19	147.67	73.93

Ocean. We assume that total ocean area of Fiji can sequester 7,172,400 tCO₂ annually. In the case of the ocean, only the social benefits of annual CO₂ sequestered are calculated and not the social benefit of avoided CO₂ emissions, as the case of coastal resources. The social benefit of carbon sequestration is estimated as FJ\$ 6.77 (US\$ 3.39) per hectare per year, totalling FJ\$ 873.33 million (US\$ 437.31 million) per year in global social benefits by the Fijian EEZ (Table 29).

Seagrass beds. According to McKenzie and Yoshida (2010) the average value of seagrasses for their nutrient cycling service and the raw product they provide has been estimated at US\$ 19,004/ha/year (1994 prices), which converted into prices of 2014 would be FJ\$ 73,992.17 (US\$ 36,992.17) per hectare per year. Since area of seagrass is unknown, total value was not calculated and we only estimate the values per hectare per year. The social benefit of carbon sequestration of intact seagrass beds is FJ\$ 536.13 (US\$ 268.40) per hectare per year (Table 29), which in US\$ results from multiplying 4.4 tCO₂eq/ha/year by US\$ 61/tCO₂/year. The net present social value of avoided carbon emissions if seagrass beds are protected is FJ\$ 60,616.9 (US\$ 30,346.4) per hectare. This value is particularly relevant for evaluating potential carbon credits. The social benefits of carbon sequestration plus avoided emission is calculated as FJ\$ 1,515.42 (US\$ 758.66) per hectare per year Table 30 . (Appendix III: Carbon calculations). This value is particularly relevant for evaluating potential carbon credits and is discussed in detail in Appendix III: Carbon calculations.

¹⁸ Ground and biomass C released are not included in this table.

Tidal salt marshes. As in the case of seagrass beds we have no information on the area of salt marshes in Fiji. Therefore we only report the unit values per hectare. The social benefits of CO₂ sequestration by tidal salt marshes was estimated as FJ\$ 971.12 (US\$ 486.17) per hectare. The net present social value of sequestration plus avoided carbon emission is FJ\$ 110,397.5 (US\$ 55,267.9) per hectare. The social benefit of carbon sequestration plus avoided emissions, is estimated as FJ\$ 2,759.94 (US\$ 1,381.70) per hectare per year (Table 30). (Appendix III: Carbon calculations).

Mangroves. Following Murray et al. (2010), we assume that mangroves sequester 6.32 tCO₂eq/ha/year. The 38 500 hectares of mangroves in Fiji result in a social benefit of carbon sequestration of FJ\$ 770.08 (US\$ 385.52) per hectare per year and a total global social benefit of FJ\$ 29.65 million (US\$ 14.84 million) per year (Table 29). The net present social value of sequestration plus avoided carbon emission from conserving mangroves is FJ\$ 153,423.4 (US\$ 76,807.6) per hectare with a national value of FJ\$ 5,906.8 million (US\$ 2,957.09 million). Annually, the social benefit of carbon sequestration plus avoided emissions by mangroves is estimated as FJ\$ 3,835.58 (US\$ 1,920.19) per hectare per year totalling FJ\$ 147.67 (US\$ 73.93) million (Table 29). (Appendix III: Carbon calculations).

6.6.4 UNCERTAINTY

The principal source of uncertainty is the lack of reliable *baseline* information on mangroves, including amounts and characteristics of soil sediments, composition of organic matter, sediment dynamics (e.g. the sediment stratification dynamic and distance to main river deltas, distance to streams) and extent of mangroves. The most recent data on mangrove area is 30 years old (Watling 1985). Zoning the mangrove area by these kinds of attributes would lead to more accurate estimates of the potential level of carbon storage and rates of carbon release on clearing and deforestation. Drainage of mangroves or marshes for agriculture should yield different levels and timing of carbon release than drainage for urban development. Rates of land use conversion of mangroves and the state of conservation of mangroves in Fiji are unknown. Another potential impact on the ability of mangroves to sequester carbon is the degree to which they are subject to (natural) coastal erosion. There is no information on extent of tidal marshes and seagrass in Fiji let alone their conservation status.

This absence of information on the rates of destruction and degradation of coastal resources is a challenging issue for policy-makers who wish to implement conservation mechanisms similar to REDD+, given that REDD+ is based on the principle of paying for reduction of emissions. More comprehensive information on carbon sequestration and emissions in Fiji would be required in order to implement a bio-finance mechanism such as REDD+.

Satellite imagery and GIS technology is available for Fiji and could be used to build and maintain a national inventory of natural coastal and marine resources which could also then monitor, at a broad scale, resource changes (state and area). This information is crucial to support more sustainable management of natural resources.

6.6.5 SUSTAINABILITY

The human benefits from carbon sequestration and avoided emissions are ongoing. However, values would be reduced if ecosystems are subjected to other human uses that are damaging (e.g. unsustainable mangrove harvesting or clearing for development).

6.6.6 DISTRIBUTION

At the moment, the benefits of this ecosystem service accrue to the global community. Theoretically, a system of negotiation at country level could allow Fiji to benefit from selling carbon credits internationally. Once negotiated and traded, a government agency could then distribute the *revenues* obtained. However, support for such negotiations requires significant resources and the monetary benefits cannot be guaranteed.

6.7 RESEARCH, EDUCATION AND MANAGEMENT

The marine environment, particularly the deep ocean, is a poorly known scientific frontier. If Fiji's marine ecosystems and their productive capabilities are significantly damaged or destroyed, the cost to the economy would be enormous and long-term. Alternatively, the significant benefits, discussed in this report, could be enjoyed by society in a sustainable manner over the long term if the ecosystems were managed well. Natural and social science research and education play a pivotal role in identifying both costs and benefits in this regard including work done on biodiversity protection as a way to ensure ecosystem integrity.

In the Pacific Islands, which are surrounded by large expanses of ocean and where much of the *economic activity* is either directly or indirectly dependent on the marine environment, there has been a significant flow of grant and aid monies into ocean management and development work. This work includes scientific studies of fish stocks, aquaculture experimentation, seabed exploration and training and capacity-building in marine and coastal development. Donor and development agencies give high priority to the advancement of the marine sector because of the potential it holds and because it is vulnerable. International agencies such as the World Bank, the Asian Development Bank, the European Development Fund, United Nations Development Programme and developed countries such as Australia, New Zealand, Germany and the USA all place high priority on research and education in the marine sector. Tertiary institutions in Fiji such as the USP and the Fiji National University also have dedicated study programmes and identified research priorities focused on the marine sector.

6.7.1 IDENTIFY

Research and education refers to the opportunity that marine ecosystems and coastal areas offer for research and education initiatives, including providing research opportunities, development of new management approaches and providing a living classroom in which students can learn about natural systems.

Research and education also relates to the importance of local and traditional knowledge. Currently, NGOs have been adopting traditional resource management skills from local communities to improve local resource management. Therefore, community management decisions are informed by local ecological knowledge (Hastings et al. 2012). The FLMMA network promotes the use of local environmental knowledge as a management foundation. The FLMMA have value based on the endowment of local ecological and management knowledge. This value can be increased by adding scientific findings into decision-making as well. An indication of the *economic value* of research into marine ecosystems is the amount of research funds that relate to marine and coastal resources.

To identify the value of research and education attributable to marine ecosystems, it is important to identify those studies, research and programmes funded by donor agencies or institutions that relate to at least one of the marine ecosystems and/or its resources. Disaggregated information to this effect is not available in the public domain. Annual funding cycles differ among the agencies and institutions; funds are often allocated on thematic areas and are multi-sectoral or multi-pronged, thus difficult to separate components especially for the marine sector.

Research and education on marine and coastal ecosystems can be qualitatively assessed by identifying the institutions that largely undertake and administer these activities. These include marine-related programmes of tertiary training institutions, environmental NGOs and designated government departments such as Fisheries, Environment, *iTaukei* Affairs and Tourism. Identification of donor priorities and assistance projects can also provide some guidance on the levels of support for research and training in the marine sector. Table 31 provides a list of some donor agencies that currently fund various types of research and training related activities in the marine sector at the USP.

TABLE 31 • Potential donor agency funding and areas of specific interest in the marine sector

Donor agency	Fund name	Areas of interest related to marine sector
Embassy of the United States of America	Pacific Island Fund for small development grant	Environment, science, technology, health
New Zealand Aid Programme	Pacific Island country participation fund	Regional and international meeting attendance and participation
New Zealand government community matters	Pacific Development and Conservation Trust	Pacific development and conservation
Government of Canada	Canada fund for local initiatives	Sustainable economic development
The Sasakawa Peace Foundation	The Sasakawa Peace Island Nations Fund	Maritime management, education and information sharing
The Mohamed bin Zayed Species Conservation Fund	The Mohamed bin Zayed species Conservation Fund	Science, conservation
National Geographic	Conservation Trust	Innovative solutions to conservation and management
Pacific Seabird Group	Conservation financial grant	Seabird conservation, restoration activities
PADI Foundation	Research and education in marine conservation	Underwater science, environmental projects, education
Turtle Conservation Fund	Turtle conservation fund	Turtle conservation
Australia and Pacific Science Foundation	Ecology, research and conservation	Land, water, animals
Global Environment Facility	Small grants programme	Biodiversity, climate change, international waters
UNDP and World Bank	Climate finance option	Climate adaptation, mitigation, capacity-building, technology
Global Development Network	Regional research	Development topics relevant to regions
Alexander von Humboldt Foundation	International climate protection fellowships	Climate change related topics

Source: USP Research Office

A number of international NGOs are also actively pursuing environment-related research and training work that mostly focuses on the marine and coastal environment. IUCN Oceania, for example, has two projects that directly focus on the marine ecosystems and are being implemented in Fiji: the MACBIO project and the Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL) project. Most other work of IUCN Oceania also deals with cross-cutting issues that are dependent on the biological integrity of the marine ecosystems. Likewise, the Wildlife Conservation Society (WCS) has a dedicated Fiji country programme under three broad areas: science, management and communication (Wildlife Conservation Society 2014). A range of activities address the three broad areas which are implemented in an integrated manner that combines scientific research to inform policy with communication as a means of disseminating research information. WCS has three focus areas: integrating ecosystem-based management and adaptation principles into planning for natural resources management; designing protected area networks to strengthen resilience to climate change disturbances and preserve ecosystem services; and strengthening local and national capacity for management planning and enforcement (Wildlife Conservation Society 2014). Indeed, all three areas of work are directly related to scientific research and education through awareness. A key feature of the work of WCS in Fiji has been the study undertaken on the Vatu-i-Ra Seascape which has looked at the resource status and its potential values (Wildlife Conservation Society 2014). This area provides a unique ecological value that is located between the two main islands. It incorporates four provinces: Bua, Ra, Lomaiviti and Tailevu and includes their traditional fishing grounds and offshore channels (Wildlife Conservation Society 2014).

Other NGOs such as Conservation International (CI) work on projects that address overfishing, ocean acidification, climate change and habitat destruction and cover 23 countries and territories in the Pacific including Fiji. The focus of CI's Pacific Ocean seascape programme is on ocean health through creation and strengthening of MPAs and networks. Similarly, WWF Pacific also has programmes that focus on conservation projects that have marine resource orientation. Under the South Pacific Policy Initiative, of which Fiji is a member, is a project on building science capacity in Bismarck–Solomon Seas and Fiji Marine Eco-regions. Currently, WWF Pacific has a programme on whale sanctuaries and one on shark conservation in Fiji.

Dedicated educational programmes focused on coastal and marine resources are part of the School of Marine Studies at the USP where much of the research and field work is conducted locally. In addition, the Fiji National University offers certificate and trade diploma programmes in applied fisheries.

A number of programmes that are directly funded by international organisations that focus on thematic areas such as climate change, poverty alleviation and rural development also have sub-components that may have marine research focus.

6.7.2 QUANTIFY

The diverse activities that constitute research within the marine environment, the different educational programmes and their various sources of funding, the duration of funding and project life all make it difficult to quantify the level of benefits accrued by marine and coastal ecosystem services on a national scale. There are no data in the public domain that quantify the value of various projects. For example, the annual reports of key NGOs such as WCS, IUCN, WWF or CI do not provide any quantitative values or figures on funds allocated to different projects.

Quantifying the value of research also requires defining the parameters for measurement such as the specific target of the funding; for scientific investigation; or for a range of activities related to knowledge generation and maintenance of biodiversity and natural systems integrity. For example, MACBIO targets the latter as do most the activities of WCS. Quantification of local research and education activities in coastal and marine areas is much easier. For example, the study on *total economic value* of the Navakavu LMMA area by O'Garra (2007) included research and education as one component of the value of coral reefs.

6.7.3 VALUE

The value of research and education of the Navakavu LMMA included costs associated with field visits by researchers from USP and other institutions, research and monitoring work by FLMMMA and field trips by USP students (O'Garra 2007). The total amount paid to the community between October 2005 and January 2007 was estimated as FJ\$ 8,137.17. Researchers on average paid FJ\$ 10 per day per person for catering which amounted to FJ\$ 1,630. Deducting the cost of food from this gave a net benefit of FJ\$ 6,810 (O'Garra 2007).

A number of local coastal communities have similar arrangements for their LMMAs and may also host occasional researchers and students. Another local example of research and education in the coastal area is the annual field trip by marine studies students to Qoma Island in Tailevu Province. A total of FJ\$ 35 a day is paid to the village for each student which includes accommodation and three meals. In 2014, there were 90 students and a total of FJ\$ 3,150 was paid to the village for research access to their fishing grounds. According to anecdotal information, the cost of hosting student is about FJ\$ 15 in terms of food, time and labour. Therefore, the annual net benefit to Qoma from USP students' field trip would be about FJ\$ 1,800 (Administrative Officer, School of Marine Studies, USP, pers. comm. 2014).

6.7.4 UNCERTAINTY

Uncertainty is largely due to the lack of availability of disaggregated information on the value of research projects and educational activities specifically associated with coastal and marine ecosystems. Often funding is available under thematic areas and has multiple and overlapping objectives, thus making distinction between specific allocations difficult unless financial source documents or accounting records are accessible. Often this type of information is not available in the public domain even though such information may not be sensitive. Sources of funding are usually competitive and thus, sharing of such details remains a constraint.

Given that marine science is expanding as a field, it is likely that research and educational activities pertaining to ocean resources will increase, particularly in the Pacific region where land resources are limited. Therefore, it is highly likely that capturing the benefits of research and education will be increasingly important to our understanding of the total value of the marine and coastal ecosystems.

6.7.5 SUSTAINABILITY

Ocean resources are seen as an important source of income and livelihood for Pacific Island economies including Fiji. Considering the number of tertiary institutions and NGOs as well as donor agencies present in Fiji, it is highly probable that funding will increase in the near future in this area. On the whole, research and education activities are either not extractive or damaging or else at a scale where the small amount of impact is likely to be sustainable.

6.7.6 DISTRIBUTION

The distribution of research and educational funds is most complex given the diverse sources of donor funds and the conditions that are attached to those funds. The direct beneficiaries are, however, the researchers and project implementers themselves, the communities where capacity-building and awareness programmes are held, students and the government. In the case of collaborative research, the benefits accrue to some combination of the above, as well as to any overseas or regional partners brought in for the work. In the case of technical support and technology transfer, the benefits can be shared between the donor and the recipient. For example, consultants or researchers from the donor nation would often repatriate the payments done for his or her services. They would also purchase technical equipment from the donor country. The local people and students benefit from knowledge and skills transfer.

6.8 OTHER VALUES

A number of other ecosystem values result from the existence of the marine and coastal resources such as cultural values and values that are by-products from natural processes of ecosystems. The non-monetary nature of some of these values makes quantification challenging. There is also a danger that any quantification can lead to its gross underestimation which can undermine the importance of the values.

6.8.1 CULTURAL AND LIFESTYLE VALUES

Notable studies that identify the cultural significance of marine resources or objects derived from the ocean in the Pacific Islands include studies by Johannes (1981) and Hviding (1996). Significance of social and cultural values or marine resources in Fiji is described in Veitayaki et al. (2002) and Veitayaki et al. (2011).

Cultural values may refer to the traditional and historic values that are supported or defined by, or entwined with, either extractive or non-extractive use of marine resources. In Fiji, a number of marine resources are not eaten by certain groups of people because the resources are seen as totems. For example, the people of Cakaudrove do not eat sharks because they symbolise *dakuwaqa* or their shark god. Likewise, people of Koro Island do not eat turtles because it is their totem. Instead, they practice 'turtle calling' which is calling to the spirits that protect them. The use of whale's tooth or *tabua* is still prevalent in the Fijian cultural kava ceremony and in settling disputes during conflicts. The offer of turtles as the most prime food to the high chief also signifies respect for elders. On the island of Vatulele, people do not eat the red prawns that are only found in the waters around Vatulele in Fiji.

The Sigatoka coastal sand dunes have been designated as a National Park with approximately 650 ha of geomorphological, ecological, cultural and aesthetic attributes. Excavations at the site have given clues to scientists about the migration patterns of the indigenous people (National Trust of Fiji 2014).

A number of the cultural and ceremonial values are associated with traditional cultures and face threats from modernisation, cultural changes that are brought about by western ideologies, science and technology. In addition, the degradation of marine resources can impact on the frequency and nature of traditional uses to which they are applied.

6.8.2 MARICULTURE

While aquaculture in Fiji has been expanding with an increase in tilapia farms, there has been renewed interest in mariculture that largely focuses on shrimp, pearls and seaweeds, and more recently on mangrove crabs and cultured live rock. Typically mariculture production comes under the Fisheries Department as part of the broader category under aquaculture.

The volume and value of seaweed (*Eucheima*) production has fluctuated since 2006 (Table 32; Figure 11). The fluctuations are partly because of changes in market price but also the commodity is affected by storms and cyclones. The low technology and short growth cycles are often attractive to rural communities where sources of income are limited.

Shrimp farming is an attractive alternative because of its high demand and high value but the production of shrimp has been dropping since 2006 (Table ; Figure 12). Shrimp farming requires a high level of technical skills in rearing and maintenance. One of the main concerns with shrimp farming has been the lack of supply of post larvae for stocking as well as the high cost of feed.

There are currently six pearl farms on the island of Vanua Levu and two farms on Viti Levu. In 2010, the farms were extensively damaged by Cyclone Thomas and production was dramatically lower (Table 32). Pearls are also important export commodity from coastal areas.

TABLE 32 • Production of seaweed, shrimp and pearls by mariculture in Fiji, 2006-2012

Commodity	Unit	2006	2007	2008	2009	2010	2011	2012
Seaweeds	Volume (tonnes)	115	60	64.6	44	56	46	27
	Value (FJ\$ 000)	92	48	51.5	44	56	46	34.9
Shrimp	Volume (tonnes)	13	10.5	9	0.5	0.3	0.6	
	Value (FJ\$ 000)	520	420	360	20	9	18	
Pearls	Number	41,802	39,407	53,811	55,324	17,672	35,914	

Source: Fiji Fisheries Department 2014

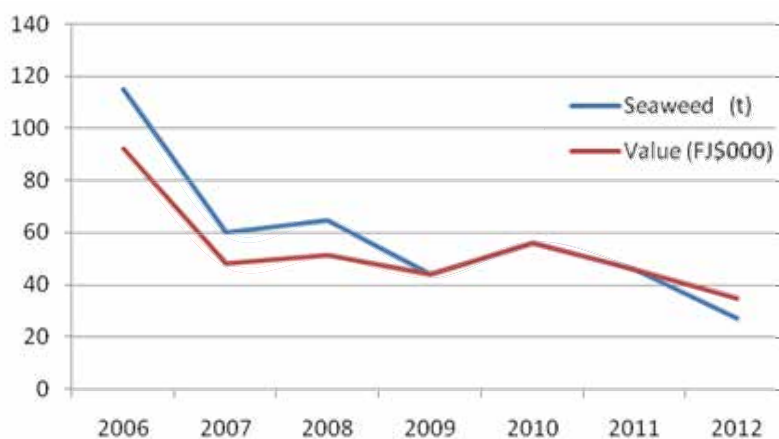


FIGURE 11 • Quantity and value of seaweed production by mariculture in Fiji

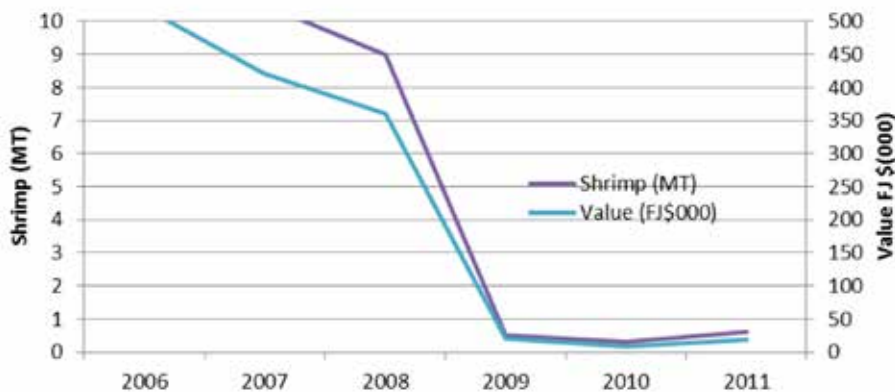


FIGURE 12 • Quantity and value of shrimp production in Fiji, 2006-2011

A study by Lal and Cerelala (2005) assessed the financial and economic desirability of cultured coral and live rock products in comparison with those obtained from the wild. The study showed that coral and live rock is an important source of income for exporters of aquarium products and resource custodians. The study pointed out that while live rock culture is financially viable, it was seen as less attractive to villages compared to wild harvests because of the investment and maintenance costs involved in engaging in culture of rocks.

Nevertheless, the situation is gradually changing as exporters of aquarium products are increasingly using cultured live rock because of the need to protect natural coral reef areas. Extraction of corals and live rock from the wild remains a contentious issue but the exports are limited by permits and fall under the Convention on International Trade in Endangered Species export documentation scheme.

Currently, the Fiji Government gives high priority to mariculture because of its potential to address food security and to provide income via exports. A number of commodities such as mangrove crabs are at various stages of experimental trials. The Fiji Crab Company is a joint venture that has been operating a crab farm in Navua; live crabs are sold for between FJ\$ 25 and FJ\$ 30 per kg (Manager, Fiji Crab Company, pers. comm. 14 September 2014). Other commodities under trial include sea cucumbers, trochus and giant clams.

The extensive reef and mangrove areas in Fiji have high potential for mariculture development. Maintaining a healthy coastal environment is critical for the realisation of this potential.

6.8.3 BIO-PROSPECTING AND OTHER DIRECT USE OPTION VALUES

One of the most important applications of knowledge about the chemical and biological properties of marine plants and animals across the world is to identify potential drugs to cure diseases such as cancer. The potential in this area is yet to be explored because many studies are still at an experimental stage. Setting an appropriate institutional framework to regulate research and studies in this area and to ensure equitable sharing of benefits among the stakeholder is important.

Information on bio-prospecting is often limited and integrated with research and education information. In Fiji, the Institute of Applied Science at USP is the main laboratory involved in bio-prospecting with overseas institutions. Some of the current work includes identifying metabolites from the Fijian marine sponge *Cibrochatina* sp., identifying antibacterial compounds from the marine sponge *Dacylosporgia metachromia* and exploring other drugs from marine microbes (Institute of Applied Science Drug Unit 2013). The real value of these activities can only be realised once trials for these drugs are successful. Aside from the benefits of marketing any consequent products, another measure of the benefit would be savings from reduced health costs.

6.8.4 NON-USE VALUES

An important aspect of *non-use values* is the existence of traditional ecological knowledge about the marine environment by the people who are directly dependent on these environments. For example, the presence of certain species in particular areas of the fishing grounds enables people to determine seasonality, weather patterns and spawning periods of either the same species or other related species. For example when the corals spawn in October and November period, people in Fiji know that the sea worm *balolo* will rise.

People are able to determine their fishing patterns and organise their daily activities based on their ethno-biological knowledge and experience. Any threat to species or habitats that comprise part of traditional ecological knowledge threatens practices that have been part of the cultural heritage of Fiji for centuries.

6.9 SYNTHESIS OF RESULTS

This report provides estimates of the value of inshore and offshore fisheries, tourism, coastal protection and carbon sequestration by ocean and coastal resources in Fiji (Table 1, page 2). We were not able to provide a value for mineral and aggregate mining or research and education.



7 DISCUSSION

Our estimations are well below the mean total monetary value of a bundle of ecosystem services calculated by de Groot et al. (2012). For example, de Groot et al. (2012) estimated values (2007 prices) of Int\$¹⁹ 491/ha/year for the open ocean, Int\$ 352,915/ha/year for coral reefs, Int\$ 28,917/ha/year for coastal systems and Int\$ 193,845/ha/year for coastal wetlands. This likely reflects the more comprehensive range of ecosystem services that was used in their analysis. This comparison emphasises that our estimates do not reflect the *total economic value* of Fiji's marine and coastal ecosystems but represent absolute minimum values.

The lack of information about Fiji's marine resources is a major challenge for ensuring their sustainable use. A precondition for achieving sustainability is the ability of stakeholders and decision-makers to make informed decisions. As a first step in building information, an official and accurate *baseline* of marine and coastal resources is needed; this must include multi-level and spatially referenced ecological, climatic, socio-cultural and economic information. Geographical information for delimiting the area and boundaries of resources may be available from satellite imagery and GIS technology. Ecological information is crucial to understand the nature of resources and their dynamic as ecosystems that are interdependent and connected to each other. Local climatic information is also important because it determines not only ecosystem dynamics but also impacts on human populations. Socio-cultural information is needed to understand the interaction between marine resources and people and how cultural and social factors are interlinked with the availability of such resources. Economic information is important because decisions about use or overuse have consequences for the level of scarcity of natural resources and therefore their prices and sustainability. *Total economic value* aggregates all aspects of human benefits derived from, for example, coastal and marine ecosystems. The estimation of these values in a measurable and understandable unit, such as money, allows stakeholders and decision-makers to take better management and use decisions regarding marine resources, which may help in achieving sustainable use.

In Fiji, there is no quota for inshore fisheries, and the control of overharvesting in inshore fisheries relies on communities to engage in some degree of fisheries management and/or conservation. However, the success of local conservation initiatives depends on communities' skills of self-governance and the role that partner organisations play in the FLMMMA network. The government relies, to a degree, on the FLMMMA network to achieve sustainable outcomes. However, a series of challenges must be addressed to empower the FLMMMA network and communities. Despite the high level of engagement in conservation across many levels — four government agencies, 23 NGOs, at least a dozen community-based groups and about 150 professionals currently working on conservation initiatives — the Austral Foundation was pessimistic about the effectiveness of conservation initiatives in Fiji (Austral Foundation 2007). In their report they claimed that most projects failed to extend beyond the pilot phase and communities saw projects come and go, failing in long-term capacity-building.

Awareness of the true value (in economic and *welfare* terms) of marine and coastal resources can encourage actions to assure their sustainable use. Furthermore, knowledge of the *total economic value* of marine and coastal resources, including less obvious non-market values, can empower local communities and governments to take informed management decisions. The availability of relevant information on *economic value* can also help local communities to participate in, and potentially lead, the decision-making process, a practice usually encouraged by local governments and NGOs.

The estimated values of coastal and marine resources provided in this report offer the possibility of better informed decision-making by a wide range of people. For example, Laurans et al. (2013) provided a list of stakeholders that used ecosystem services valuation for coral reefs in the South Pacific, including development banks, environmental agencies and NGOs, government planners, environmental government agencies and local stakeholders such as chiefs and MPA managers.

There are over 10,000 km² of Fijian waters allocated to LMMAs. However, a decline in the availability of financial resources to support marine resource management has reduced the effectiveness of these and other conservation initiatives already implemented (Mills et al. 2011a). In addition to financial strictures, major problems were reported

19 International dollars, a hypothetical unit of currency that has the same *purchasing power parity* that the US dollar has in the USA at a particular point in time, in this case, in 2007.

in marine resource management using three different types of management actions: permanent closure to extractive activities; partial closure with controlled access; and partial closure with uncontrolled access (Mills et al. 2011a). Challenges were generally related to the small size of closed areas, the reluctance of villagers to close fishing grounds and that communities were unlikely to distribute closures evenly across ecosystems. Villagers are more conscious of the short-term than long-term *opportunity costs* of conservation since they face immediate decisions regarding food and income needs. With declining resources, fishers apply greater fishing effort in the form of travelling beyond the limits of their typical fishing grounds.

Techera and Troniak (2009) remarked that there were gaps in the legal framework for conservation in Fiji, especially in terms of enforcement in MPAs and LMMAs, legal recognition of LMMAs and alignment of Fijian laws with international conventions and agreements. Lane (2008) remarked on the lack of integration and coordination, the need for system-wide governance reform, and the high degree of centralisation as an impediment to local decisions. All these factors reveal limitations to or considerations regarding the capacity for successful local governance of coastal management in isolation of other governance structures or decision-making forums.

Clearly data on the value of coastal and marine resources can help in taking decisions aimed at, for example, an international financial mechanism like REDD+ to encourage stakeholders to relinquish opportunities to degrade or convert coastal to other uses (e.g. conversion and drainage of mangrove forests or salt marshes) (Murray et al. 2010). Due to mangroves' ability to store carbon, they are good candidates for the REDD+ program (Manley 2012; Ammar et al. 2014; Thomas 2014). These authors also identified the need for a complete assessment of environmental services from mangroves to evaluate their potential to participate in other incentive-based conservation programs besides REDD+. In fact, blue carbon is not included in REDD+ and there is still a need for the negotiation of a financial mechanism similar to REDD+ to protect blue carbon sinks like mangroves, seagrass beds or coral reefs (Ammar et al. 2014). Implementing such recommendations could help avoid the release of carbon in organic sediments and matter sunk in mangroves, marshes and seagrasses in Fiji (Currie and Wowk 2009). At the local level, a payment mechanism could create incentives to maintain ecosystems that sequester carbon. It could also compensate villagers for at least part of the *opportunity costs* they bear to conserve environmental services that are globally relevant.

In his guidelines for MPAs, Kelleher (1999) recommends assurance of the financial sustainability of MPAs and remarks on the need to distinguish between two main cost components: compensation to local people for benefits foregone by establishment of the MPA; and the operational and management costs incurred by implementing the MPA. Compensation could also be relevant for other environmental uses in which the economic beneficiaries of local environmental stewardship activities (e.g. the tourism industry) should compensate locals for both their stewardship and for the disturbances or costs imposed by the industry (social, cultural and ecological). Levett and McNally (2003) identify several concerns with regard to tourism as an engine of economic development in Fiji: consideration of the carrying capacity of Fijian resources to support tourism; assurance of equitable distribution of earnings from tourism among local villagers; reduction in the amount of earnings leaking out of the country; and the development of instruments such as user fees for tourism that could help assure better distribution among locals of earnings from tourism.



8 RECOMMENDATIONS AND SUGGESTIONS

We recommend that any new information relevant to marine resource management (e.g. information on marine *ecosystem service valuation*) be shared among relevant stakeholders (e.g. government departments, local community parties and conservation partners) so that it can be incorporated into management planning. In addition, we suggest that institutional arrangements be established to ensure that this occurs. At a local level, a case study from Kubulau may serve as a template for other parts of Fiji. In this case study, customary management strategies that were adaptive and could adjust to new information were adopted (Weeks and Jupiter 2013).

The marine and coastal ecosystems surrounding Fiji have contributed to the development of tourism activities. Both local and international tourists come to Fiji to enjoy the ocean scenery, diving, snorkelling, parasailing and game fishing activities. However, the oceans of Fiji are in danger of mismanagement. Tourism operators earn millions of dollars every year from marine and coastal ecosystem-related activities. However, in return they pay nothing towards the management of those marine and coastal ecosystems or the local communities that also use them. A central question that should be addressed in a sustainable management plan for tourism is how tourism can contribute to sustainable management of marine resources and poverty alleviation not only in areas surrounding sites of touristic interest but also to the rest of the country.

Any policy mechanism for encouraging sustainable management of coastal and marine resources, e.g. equivalent to REDD+, must be complemented with policy mechanisms for local users, for example, payments for environmental services, royalties or compensation for resource use (as in tourism) or environmental easement contracts. The creation of a government conservation fund that would administer and finance conservation initiatives using the *revenues* from environmental taxes would certainly facilitate the implementation of conservation policies. There is space for improved policy instruments as better, more detailed and dependable information becomes available on the value that the people of Fiji derive from environmental services supplied by Fiji's marine and coastal resources.



9 CAVEATS AND CONSIDERATIONS

Despite advances in estimating the value of marine and coastal resources, caution should be exercised when using value estimations as the primary or leading source of information for decision-making. This is because incomplete information may result in the estimation of partial values that could be mistaken for *total economic values*. For example, Lal (2003) points out that a shortcoming of economic valuation-based decision-making is the lack of ecological information available in small island nations in the Pacific. Therefore, the recognition of incomplete ecological and economic information suggests the need for decision-making in which estimated values complement, but do not necessarily lead, the decision-making process. As knowledge about ecosystems and their interaction with human populations is improved, the accuracy of value estimation of resources will also be improved.

Estimates of the value of marine and coastal resources available in this report are based on strong assumptions. Although these estimates reveal a notion of *economic value*, it is far from complete given that our assumptions are based on market goods. For example, in the case of fisheries, by estimating the value using the production approach we miss a set of other valuable non-market goods and services, their ecosystems functions and their impact on the level of *welfare* of human population. Similarly, the value of tourism is based on expenditure made by tourists in travelling, visiting and enjoying the many tourist destinations and facilities of Fiji which may serve as a proxy for the *willingness-to-pay* for tourism in Fiji. However, many value components that may affect the level of *welfare* of the people partaking in these activities have not been taken into account. The estimates provided in this report are therefore minimum values.



10 FUTURE DIRECTIONS

Further ecological and socioeconomic research should aim to improve understanding of the human relationship with, production and consumption of, and the system dynamics of marine and coastal resources. A *baseline* of information is necessary to determine priority areas for management and conservation action. After establishing a *baseline*, further efforts should be made to improve information on the value of marine ecosystems services by conducting representative survey sampling.

These minimum requirements for further information will provide key data to allow for more sustainable management planning and also will shed light on possible incentive mechanisms for conservation.



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13 APPENDIX I GLOSSARY

- Avoided damage cost valuation method:** A cost-based valuation technique that estimates the value of an ecosystem service by calculating the damage that is avoided to infrastructure, property and people by the presence of ecosystems.
- Baseline:** The starting point from which the impact of a policy or investment is assessed. In the context of ecosystem service valuation, the baseline is a description of the level of ecosystem service provision before a policy or investment intervention.
- Beneficiary:** A person that benefits from the provision of ecosystem system services.
- Bequest value:** the value to the current generation of knowing that something (e.g. pristine coral reef) will be available to future generations.
- Constant prices:** Prices that have been adjusted to the price level in a specific year. Constant prices account for inflation and allow values to be compared across different time periods.
- Consumer surplus:** The difference between what consumers are willing to pay for a good and its price. Consumer surplus is a measure of the benefit that consumers derive from the consumption of a good or service over and above the price they have paid for it.
- Cost-benefit analysis:** An evaluation method that assesses the economic efficiency of policies, projects or investments by comparing their costs and benefits in present value terms. This type of analysis may include both market and non-market values and accounts for opportunity costs.
- Direct use value:** The value derived from direct use of an ecosystem, including provisioning and recreational ecosystem services. Use can be consumptive (e.g. fish for food) or non-consumptive (e.g. viewing reef fish).
- Discount rate:** The rate used to determine the present value of a stream of future costs and benefits. The discount rate reflects individuals' or society's time preference and/or the productive use of capital.
- Discounting:** The process of calculating the present value of a stream of future values (benefits or costs). Discounting reflects individuals' or society's time preference and/or the productive use of capital. The formula for discounting or calculating present value is: $\text{present value} = \text{future value}/(1+r)^n$, where r is the discount rate and n is the number of years in the future in which the cost or benefit occurs.
- Economic activity analysis:** An analysis that tracks the flow of dollars spent within a region (market values). Both economic impact and economic contribution analysis are types of economic activity analysis.
- Economic activity:** The production and consumption of goods and services. Economic activity is conventionally measured in monetary terms as the amount of money spent or earned and may include 'multiplier effects' of input costs and wages
- Economic benefit:** the net increase in social welfare. Economic benefits include both market and non-market values, producer and consumer benefits. Economic benefit refers to a positive change in human wellbeing.
- Economic contribution:** The gross change in economic activity associated with an industry, event, or policy in an existing regional economy.
- Economic cost:** A negative change in human wellbeing.
- Economic impact:** The net changes in new economic activity associated with an industry, event, or policy in an existing regional economy. It may be positive or negative.
- Economic value:** i) The monetary measure of the wellbeing associated with the production and consumption of goods and services, including ecosystem services. Economic value is comprised of producer and consumer surplus and is usually described in monetary terms. Or ii) The contribution of an action or object to human wellbeing (social welfare).
- Ecosystem contribution factor:** The degree of association between marine and coastal ecosystems and different tourist activities.
- Ecosystem functions:** The biological, geochemical and physical processes and components that take place or occur within an ecosystem.
- Ecosystem service approach:** A framework for analysing how human welfare is affected by the condition of the natural environment.
- Ecosystem service valuation:** Calculation, scientific and mathematic, of the net human benefits of an ecosystem service, usually in monetary units.
- Ecosystem services:** The benefits that ecosystems provide to people. This includes services (e.g. coastal protection) and goods (e.g. fish).
- Ecosystem:** A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
- Evaluate:** To assess the overall effect of a policy or investment.
- Evaluation:** The assessment of the overall impact of a policy or investment. Evaluations can be conducted before or after implementation of a policy or investment.
- Existence value:** The value that people attach to the continued existence of an ecosystem good or service, unrelated to any current or potential future use.
- Externality/ies:** a side effect or consequence of an industrial or commercial activity that affects other parties without this being reflected in the cost of the goods or services involved, such as the pollination of surrounding crops by bees kept for honey.
- Factor cost:** Total cost of all factors of production consumed or used in producing a good or service.
- Financial benefit:** A receipt of money to a government, firm, household or individual.
- Financial cost:** A debit of money from a government, firm, household or individual.
- Free-on-board:** The taxable value for each fished species. This value theoretically represents the market value of the product, although this is not always the case in practice.
- Future value:** A value that occurs in future time periods. See also present value.
- Geographic Information Systems (GIS):** An information system that captures, stores, manages, analyses and presents data that is linked to a geographic location.
- Green accounting:** The inclusion of information on environmental goods and services and/or natural capital in national, sectoral or business accounts.

- Gross revenue:** Money income that a firm receives from the sale of goods or services without deduction of the costs of producing those goods or services. Gross revenue from the sale of a good or service is computed as the price of the good (or service) multiplied by the quantity sold.
- Indirect use value:** The value of ecosystems services that contribute to human welfare without direct contact with the elements of the ecosystem, for example regulating services such as plants producing oxygen or coral reefs providing coastal protection.
- Inflation:** A general rise in prices in an economy.
- Instrumental value:** The importance of something as a means to providing something else that is of value. For example, a coral reef may have instrumental value in reducing risk to human life from extreme storm events.
- Intermediate costs:** The costs of inputs or intermediate goods that are used in the production of final consumption goods. For example, the cost of fishing gear used to catch fish is an intermediate cost to the harvest and sale of fish.
- Intrinsic value:** The value of something in and for itself, irrespective of its utility to something or someone else. Not related to human interests and therefore cannot be measured with economic methods.
- Marginal value:** The incremental change in value of an ecosystem service resulting from an incremental change (one additional unit) in the quantity produced or consumed.
- Net revenue:** Monetary income (revenue) that a firm receives from the sale of goods and services with deduction of the costs of producing those goods and services. Net revenue from the sale of a good is computed as the price of the good multiplied by the quantity sold, minus the cost of production.
- Nominal:** The term 'nominal' indicates that a reported value includes the effect of inflation. Prices, values, revenues etc. reported in 'nominal' terms cannot be compared directly across different time periods. See also real and constant prices.
- Non-use value:** The value that people gain from an ecosystem that is not based on the direct or indirect use of the resource. Non-use values may include existence values, bequest values and altruistic values.
- Opportunity cost:** The value to the economy of a good, service or resource in its next best alternative use.
- Option value:** The premium placed on maintaining environmental or natural resources for possible future uses, over and above the direct or indirect value of these uses.
- Present value:** A value that occurs in the present time period. Present values for costs and benefits that occur in the future can be computed through the process of discounting (see discount rate). Expressing all values (present and future) in present value terms allows them to be directly compared by accounting for society's time preferences.
- Producer surplus:** The amount that producers benefit by selling at a market price that is higher than the minimum price that they would be willing to sell for. Producer surplus is computed as the difference between the cost of production and the market price.
- Profit:** The difference between the revenue received by a firm and the costs incurred in the production of goods and services (see also producer surplus).
- Purchasing power parity adjusted exchange rate:** An exchange rate that equalises the purchasing power of two currencies in their home countries for a given basket of goods.
- Purchasing power parity:** An indicator of price level differences across countries. Figures represented in purchasing power parity represent the relative purchasing power of money in the given country, accounting for variance in the price of goods. Typically presented relative to the purchasing power of US dollars in the United States.
- Real:** The term 'real' indicates that a reported value excludes or controls for the effect of inflation (synonymous with constant prices). Reporting prices, values, revenues etc. in 'real' terms allows them to be compared directly across different time periods. See also nominal and constant prices.
- Regulating services:** A category of ecosystem services that refers to the benefits obtained from the regulation of ecosystem processes. Examples include water flow regulation, carbon sequestration and nutrient cycling.
- Rent:** Any payment for a factor of production in excess of the amount needed to bring that factor into production (see also producer surplus and resource rent).
- Replacement cost method:** A valuation technique that estimates the value of an ecosystem service by calculating the cost of human-constructed infrastructure that would provide same or similar service to the natural ecosystem. Common examples are sea walls and wastewater treatment plants that provide similar services to reefs, mangroves, and wetland ecosystems.
- Resource rent:** The difference between the total revenue generated from the extraction of a natural resource and all costs incurred during the extraction process (see also producer surplus). Refers to profit obtained by individuals or firms because they have unique access to a natural resource.
- Revenue:** Money income that a firm receives from the sale of goods and services (often used synonymously with gross revenue).
- Social cost of carbon:** The social cost of carbon is an estimate of the economic damages associated with a small increase in carbon dioxide (CO₂) emissions, conventionally one tonne, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO₂ reduction).
- Supporting services:** A category of ecosystem services that are necessary for the production of all other ecosystem services. Examples include nutrient cycling, soil formation and primary production (photosynthesis).
- Total economic value:** i) All marketed and non-marketed benefits (ecosystem services) derived from any ecosystem, including direct, indirect, option and non-use values, or ii) The total value to all beneficiaries (consumer, producer, government, local, foreign) from any ecosystem service.
- Use value:** Economic value derived from the human use of an ecosystem. It is the sum of direct use, indirect use and option values.
- User cost:** The cost incurred over a period of time by the owner of a fixed asset as a consequence of using it to provide a flow of capital or consumption services; the implications of current consumption decisions on future opportunity. User cost is the depreciation on the asset resulting from its use.
- Utilitarian value:** A measure of human welfare or satisfaction. Synonymous with economic value.
- Valuation:** The process or practice of estimating human benefits of ecosystem services or costs of damages to ecosystem services, represented in monetary units.
- Value:** The contribution of an action or object to human wellbeing (social welfare).
- Value-added:** The difference between cost of inputs and the price of the produced good or service. Value-added can be computed for intermediate and final goods and services.
- Welfare:** An individual's satisfaction of their wants and needs. The human satisfaction or utility generated from a good or service.
- Willingness-to-accept:** The minimum amount of money an individual requires as compensation in order to forego a good or service.
- Willingness-to-pay:** The maximum amount of money an individual would pay in order to obtain a good, service, or avoid a change in condition.

14 APPENDIX II STAKEHOLDER CONSULTATION AND PARTICIPANT LISTS

Consultations and discussions were held with the following people who also provided very useful insights, guidance, ideas, policy directions, information and/or data for this analysis.

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Tengy Cement Fiji Co Ltd	Operations Manager
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Fiji Airways Ltd	Shane Hussain, Public Relations Officer
Fiji Islands Bureau of Statistics	Statistics Officer
Ministry of Lands and Mineral Resources	Malakai Finau, Director of Mineral Resources Department
Wildlife Conservation Society	Sangeeta Mangubhai, Fiji Country Programme Director
World Wide Fund for Nature	Seremaia Tuqiri, Fisheries Policy Officer
Tourism Fiji	Tupou Moefo, Information Officer
Waidroka Bay Resort	Kirsti Deacon-Smith, General Manager
Denarau Surf and Dive	Rimal Nand, Manager
Adrenalin Fiji	Sala Tuilonna, Marine Manager

15 APPENDIX III CARBON CALCULATIONS

According to Pendleton et al. (2012), 25–100% of land-based, near-surface carbon sinks (< 1 metre deep) can be released into the atmosphere as consequence of mangrove clearing, depending on the land use to which it has been converted. Also, it is expected that after clearing, 94% of biomass (aerial and underground) will be released to the atmosphere in the first four years and two-thirds of carbon stored in oceanic mangroves and one-third of carbon stored in estuarine mangroves will be released into the atmosphere over a time horizon of 30 years (Murray et al. 2010).

To calculate the avoided social cost of conservation of coastal resources (as a social benefit) we impose a conservative set of assumptions. First, 50% of near-surface carbon is released in the first seven years, and the remaining 25% is released up to year 30. Second, 75% of biomass carbon is released the first five years, the rest released over the next 10 years (total 15 years). We use a *discount rate* of 2.5%, and a 30 year horizon for ground carbon, a 15 year horizon for living biomass and perpetuity for foregone annual social benefit of carbon sequestration. Also, we assume that after 30 years, 25% of carbon remains in the ground, and after 15 years, 10% of carbon from living biomass remains. We assume a linear relationship for the carbon release rate. Thus, the total social cost of cutting one hectare of coastal resources is given by: Net *present value* (NPV) of ground C released + NPV of biomass C released + NPV Social benefit of a CO₂ reduction, where:

$$\text{NPV of ground C released} = \sum_{t=1}^7 \frac{0.5 \cdot \text{Stock} / 7 \cdot \text{SCC}}{(1 + 0.025)^t} + \sum_{t=8}^{30} \frac{0.25 \cdot \text{Stock} / 23 \cdot \text{SCC}}{(1 + 0.025)^t} \quad (\text{US\$/ha})$$

$$\text{NPV of biomass C released} = \sum_{t=1}^5 \frac{0.75 \cdot \text{Stock} / 5 \cdot \text{SCC}}{(1 + 0.025)^t} + \sum_{t=6}^{15} \frac{0.15 \cdot \text{Stock} / 10 \cdot \text{SCC}}{(1 + 0.025)^t} \quad (\text{US\$/ha})$$

$$\text{NPV Social benefit of a CO}_2 \text{ reduction} = \frac{\text{SequesteredC} \cdot \text{SCC}}{0.025} \quad (\text{US\$/ha})$$

For avoided emissions, we follow Pendleton et al. (2012) and assume 512 tCO₂eq/ha, 917 tCO₂eq/ha and 1,028 tCO₂eq/ha as potential carbon to be released into the atmosphere of near-surface carbon (sediments) for seagrasses, tidal marshes and mangroves, respectively. For living biomass, we also consider an additional 10 tCO₂eq/ha, 32 tCO₂eq/ha and 464 tCO₂eq/ha, respectively for each different ecosystem (Table 34). To obtain net *present value* of foregone benefits, we assume all carbon is eventually released. Thus we take the values from Table 28, apply the *discount rate* and put in Table 29 as *present value* of foregone benefits. Net present social value of avoided carbon emission is presented for each coastal resource (Table 30).

In order to obtain an annual value estimation of conservation, we multiply the *present value* of social benefits of carbon by the *discount rate* (Table 33).

TABLE 33 • Present value of social benefit of avoided CO₂ emissions from protection from degradation or destruction

Ecosystem	Top metre sediment / biomass / total (tCO ₂ eq/ha)	Units	NPV of SCC		Total NPV of SCC (\$ million)	
			FJ\$/ha	US\$/ha	FJ\$	US\$
Seagrass	+512	unknown	38,181.2	19,114.5		
	+10		990.5	495.9		
	Subtotal=522		39,171.7	19,610.4		
	+Foregone benefit		21,445.2	10,721.6		
	Total		60,606.9	30,332.0		
Tidal marsh	+917	unknown	68,383.1	34,234.3		
	+32		3,169.6	1,586.8		
	Subtotal=949		71,552.7	35,821.1		
	+Foregone benefit		38,844.8	19,446.8		
	Total		110,397.5	55,267.9		
Mangroves	+1,028	385 km ²	76,660.6	33,378.3	2,951.43	1,477.56
	+464		45,959.5	23,008.5	1,769.44	885.83
	subtotal=1,492		122,620.6	61,386.8	4,720.88	2,363.39
	+ foregone benefit		30,803.2	15,420.8	1,185.92	593.70
	Total		153,423.8	76,807.6	5,906.8	2,957.09





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