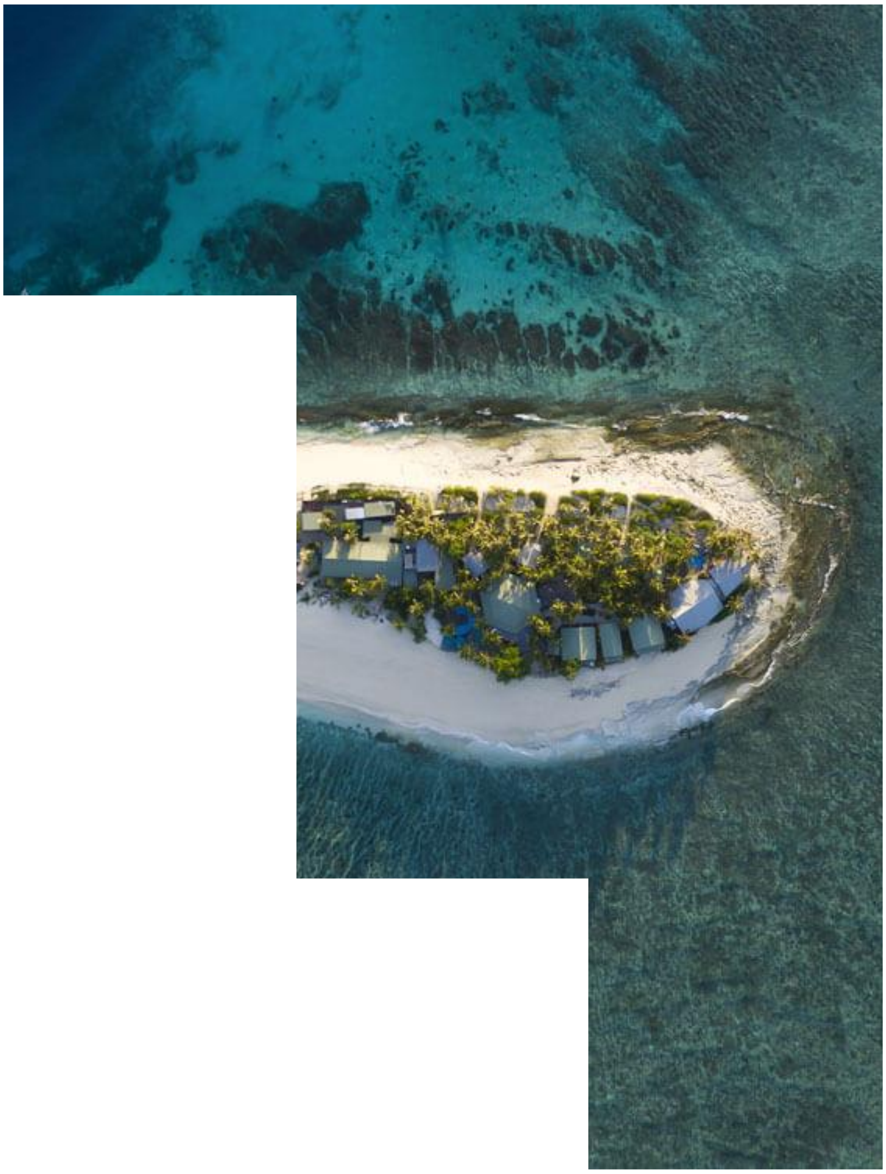
Global Ocean Accounts Partnership



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Ocean Accounting for Fiji:

A Focus on Mangroves

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Highlights

- Ocean economy is fundamental to Fiji's national economy, and for supporting the livelihoods of the Fijian people. Howåever, until recently, its value to the real economy and the society remains less readily realised.
- The National Ocean Policy (NOP) defines Fiji's agenda and initiatives on the Ocean and its management. It defines Fiji's focus on marine conservation, ocean development and related advocacy.
- Ocean accounts (OA) are an important tool for evaluating progress towards Fiji's global and domestic ocean commitments. The OA framework extends existing accounting standards to understand the contribution of ocean ecosystems to society and the economy.
- In this report, mangrove ecosystem accounts are compiled and linked to economic activities. Mangroves were selected for this study because of data availability and their economic significance in Fiji as Fiji has one of the highest mangrove coverage in the South Pacific region.
- Mangrove accounts identified that in 2016 mangrove cover was 50800 ha, a decrease of 0.9% (562 ha) since 2008.
- Majority of the mangrove populations was concentrated in the Eastern, Central and Northern provinces of Fiji in Bua, Serua, Tailevu and Rewa.
- We also investigated the economic value of mangroves in Fiji. The initial findings suggest that most significant direct benefits of mangroves are accrued to fisheries and aquaculture, construction and professional scientific services industries. We estimate close to USD20-30m value of direct UN System of National Accounts (SNA) benefits of mangroves annually Fiji.
- These estimates show that mangroves support about 0.5% of Fiji's Gross Domestic Product (GDP) and Gross Value Added (GVA). Data also show that mangrove related activities support about 3500 direct jobs which represent about 2% of all jobs created in these industries.
- We further define a roadmap to guide future research on Fiji, extending to other ecosystems in ocean sectors.

Purpose

- The report intends to provide a background on mangrove forests in Fiji, describing relationships between mangroves, the society, and the economy.
- Describes methods to compile extent and condition accounts, in addition to flows (i.e., ecosystem services) and present a pilot study estimating mangroves extent, condition and ecosystem services supply across a state in Fiji.
- Describe the methodology of compiling the SNA benefits of mangroves and present a consensus estimate of the partials and the value of direct SNA benefits of mangroves to Fiji.
- Draw tentative conclusions and suggest relevant policy imperatives related to the Ocean economy of Fiji.

Executive Summary

This initial Fiji pilot is instrumental in advancing further research and policy dialogues on Ocean Accounts. This research identified Fiji's policy priorities related to mangroves and mangroves ecosystems, developed mangrove accounts and related economic valuations, and provides a roadmap for future initiatives.

Ocean resources and their management remain strategic to Fiji, its people and their livelihoods. Due to ease of data and value of mangroves to Fiji, this study focused on mangroves forests, which can be used as a directive for future research focused on other ecosystems.

The Government remains committed to meeting the international priorities, and targets and goals described within the National Ocean Policy. Therefore, the findings from this research is expected to add value to Fiji meeting its targets on Ocean Economy and Management.

Mangroves are a wide-spread coastal habitat and of national significance in Fiji. They are found in river deltas and estuaries of all provinces, dominated by mangroves *Rhizophora spp*. and *Bruguiera spp.* Mangroves provide a number valuable ecosystem services that contribute to human wellbeing.

At present, knowledge of mangroves and their contribution to society and the economy is fragmented. While the extent of mangroves has been mapped, the estimates could be imporved and refined through higher resolution mapping and modeeling. The condition of mangroves (in terms of health and selected functions) has been documented. The estimation and valuation of services and benefits of mangroves are performed using a variety of methods, many of which are incompatible with accounts maintained by the Ministry of Economy in Fiji. To adequately manage these habitats, managers must understand their distribution and measure their importance to society and the economy, to provide more equitable and sustainable decisions.

The Ocean Account (OA) framework may be used to understand the contribution of mangrove forests to society and the economy. As an extension of international environmental-economic standards, Ocean Accounting provides a means to combine ocean information (environmental, social, and economic) in a standardised and coherent manner. Accounts that are maintained could be used to produce statistics and indicators to monitor mangrove distribution, condition, and measure the dependencies of society and the economy on the goods and services they provide, in addition to the potential impacts of human activities. The accounts may further be used to assess policies and management interventions.

Here we present a methodology for the development, maintenance, and use of mangrove ocean accounts. Compiling and maintaining mangroves accounts requires data on the spatial extent of mangroves, the primary production and associated carbon storage, and the secondary production (i.e., of reliant species) generated in these forests.

Accounts for mangrove extent and condition within Fiji have been compiled. The present accounts observe a 0.9% decrease in mangrove cover (562 ha) between 2008 and 2016. In 2016, the accounts estimated 50800 ha of mangrove cover across 10 provinces. Variables of tree height, net primary production and above-ground biomass are also estimated.

The estimates of economic accounts suggest significant direct benefits of mangroves to Fiji. The initial estimates point to about USD20-30m of direct benefits accrued to Fiji in recent years. The mangrove supported industries contribute slightly more than 0.5% to total value added and to the level of economic activity. Estimates also show that mangrove related activities direclty supports ~3500 jobs, which represents ~2% of all jobs related to this industry in Fiji.

Our findings point to some important policy directions. Policies supporting protection of mangrove ecosystems especially those exposed to informal activities need to be prioritised. Second, while mangroves remain a significant marine asset for the subsistence economy in maritime and coastal areas of Fiji, sustainability in their use is highly recommended. In addition, direct economic benefits of mangroves could be further amplified by protecting and preserving mangrove ecosystems. Furthermore, national data accounting on mangrove and other marine assets must be improved.

We envisage the following activities for post-March 2022, based on the initial outcomes of this pilot and assessment of Fiji's needs and priorities in consultation with the stakeholders,we envisage that these would be the key building blocks for advancing the initial accounts. The findings from this reportwill be instrumental in preparing a more comprehensive mangrove Ocean Accounts for Fiji. In essence, further work will allow greater understanding of the ecosystem services mangroves provide, their relevance to the economy and the Fijian community. We propose the following;

1. Estimate Fiji's most recent Supply-use and I-O tables; and develop a detailed satellite account of mangroves. The I-O based estimates provide detailed information to produce such accounts. As data become available, our initial estimates could be greatly improved.
2. Increase the accuracy of mangrove cover (for example, through high-resolution aerial/satellite imageries and ground truthing with high-resolution drone aerial surveys); and extending the work to measure the impact tropical cyclones (e.g. TC Winston in 2016) and other climatic pressures (such as climate change and sea-level rise) on mangrove ecosystems.
3. Develop relevant accounts for seagrass analysis (extent, cover economic valuation, etc). This will be an important step toward developing relevant ecosystems accounts of seagrass. Together with the present work on mangroves, it will help develop a more complete picture of the ocean accounts and ocean economy.
4. Conduct research related to fisheries (ecosystems and economic valuations) in Fiji. This is an important industry in the COVID-19 road to recovery for the Fiji economy.

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1. Introduction

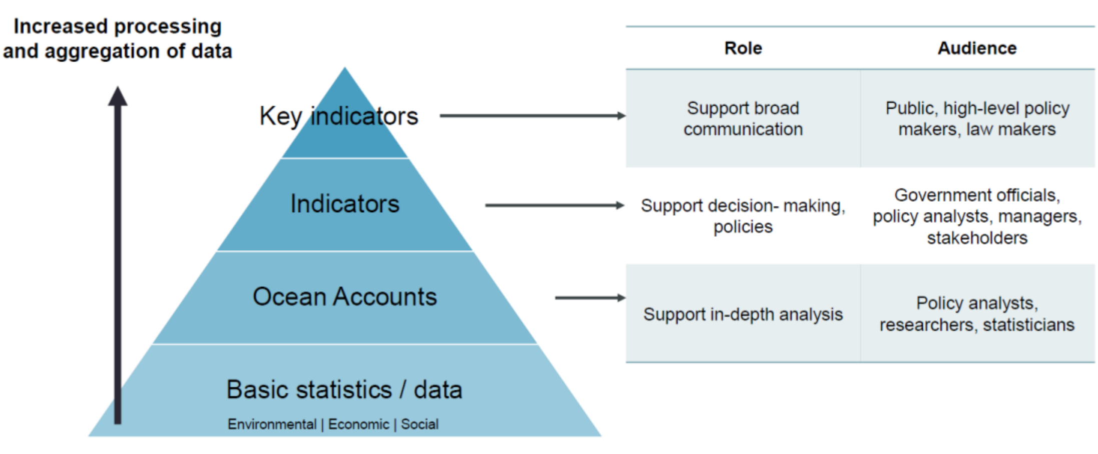
1.1. Ocean Accounting

Effective and justifiable policy relies on a diverse array of information, proper implementation, and public support across the society. This often involves balancing social, economic, and environmental considerations, framed within the context of broader socio-economic benefit and sustainability. Traditional approaches to measure the ocean environment and its links with the society and the economy have largely been ad hoc, with limited coherence between datasets and a fragmentation of information between institutions.

Ocean Accounting, as an extension of existing environmental-economic accounting and national accounting standards, seeks to identify and measure links between the ocean, society, and the economy. The UN System of National Accounts (SNA) are fundamentally used to produce macroeconomic statistics (monetary data). The United Nations System of Environmental-Economic Accounting (SEEA) provides an approach to standardise and collate information into a ‘common set of facts’, achieved through an internationally agreed upon set of definitions and classifications. It stipulates a set of principles and processes to organise social, economic, and environmental data, and ensures the information is spatially and temporally comparable.

The information produced by Ocean Accounts is aligned with other accounting standards, making them of relevance to a wide audience, from managers, policymakers, and the public (Figure 1.1). In other words, ocean accounts are integrated records of economic activity (e.g., sale of fish), social conditions (e.g., coastal employment and poverty), and environmental conditions (e.g., extent / condition of mangroves) that are compiled on a regular basis (e.g., annually) and are compatible with international statistical standards.

A simplified structure of Ocean Accounts is defined within the GOAP Technical Guidance (Figure 1.2), which relates the national economy with environmental assets and Ocean wealth. The framework identifies a range of bi-directional flows to the environment and those to the economy, importantly under the ambit of active governance structures. These provide the means to measure the impact of human activity on Oceans, and conversely the dependency of activities on Ocean health, furthering progress towards sustainability and management of the ocean economy.



Modified from UNECE 2017 & TG (v0.9)

Figure 1.1. Aggregation of data from basic statistics and data to indicators, through an accounting framework. The related table identifies the role played in communication and expected audience.

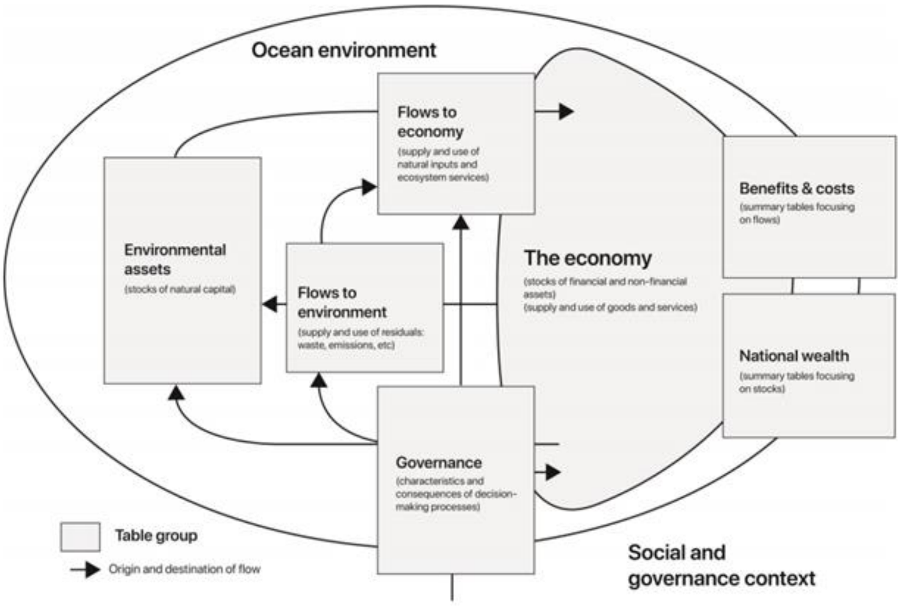


Figure 1.2. General structure of the Ocean Accounts Framework adapted from the Technical Guidance on Ocean Accounting (GOAP, 2021). An environmental asset account could be compiled through ecosystem accounting (i.e., SEEA-EA), with flows to the economy measured through ecosystem services. Statistics related to the ocean economy could be contained within an Ocean Economy Satellite Account. Details for governance accounts are described in Supplementary Materials.

Fiji's Vision for the Ocean

The national policy documents (such as the strategic and national development plans, ocean and climate policy documents, as well as the national budgets) talk of sustainability of natural resources. These, as well as the research literature and key stakeholder consultations suggest that Fiji's major concerns related to Oceans and marine resources management include mitigating climate risks directly impacting oceans/ocean assets, and promotion of the ocean economy and sustainability in the use of ocean resources. The specific policy objectives stated in the NOP document are:

1. Ongoing and increasing impact of climate change and natural disasters, against a limited domestic capacity to mitigate these challenges. As such, the Fijian Government has been instrumental advocating small states' needs to deal with global warming and climate change impacts.
2. Pollution of the sea, coastlines and waterways leading to destruction of marine habitats, biodiversity losses and persistent decline in incomes and livelihoods of people. The Ocean policy stresses the need for coordination and awareness of better household and industrial waste management practices (Environment Management Act 2005 and Litter Act 2008 are being enforced).
3. Increasing biodiversity losses with such losses being amplified by above as well as due to crimes and abuses.
4. Unsustainable and or over-use of some of the Ocean and marine resources, while unexplored economic potentials of the others. Fiji needs to adopt better management tools, including innovative technologies and environment impact assessments to carefully assess the threats and potential benefits.
5. The Government also stresses the immediate threats to Fiji's Oceans relate to territorial integrity and security, natural disasters, national security risks, pouching of marine resources, human rights abuses, transnational crimes, drug smuggling, invasive species, and international crimes.

Policy Relevance of Ocean Accounting to Fiji

Functionally, Ocean Accounts enable countries to monitor critical trends such as changes in ocean wealth, including produced assets (e.g., ports) and non-produced assets (e.g. mangroves, coral reefs); ocean-related income and welfare possibly disaggregated by activity/location (e.g. income from fisheries for local communities); and ocean-based economic production (e.g. GDP from ocean-related sectors). Some of these aspects are implicitly captured in the national accounts but are explicitly provided in the Ocean Accounts. These and other important indicators of Ocean sustainability are key to managing ocean resources - the traditional measure of GDP falls short of providing such finer details.

The approach to ocean accounting as an integrated statistical framework that supports commitments of the Fijian Government in ensuring a balance between economic development, environmental conservation, and the maintenance of ecological integrity. As a member country of the High-Level Panel for a Sustainable Ocean Economy, Fiji has committed to several transformations, including the compilation of national ocean accounts. This aligns with several national policies, including strategic and legal frameworks such as:

- the National Ocean Policy (NOP),
- the 5-year and 20-year National Development Plan (that stresses the need for sustainable development and management of Fiji's marine ecosystems),
- the Marine Economy Plan,
- the Fiji National Biodiversity Strategy and Action Plan 2020-2025,
- the Environment Management Act 2005,

- the National Climate Change Policy, and
- the National Action Plan for the Implementation of Agenda 2030 for Sustainable Development.

The Ocean accounts are designed as a single reference point for ocean data and a robust, internationally accepted information infrastructure, for diverse coastal and marine related policies. A robust information infrastructure (such as the OA) is critical for national ocean development and management policies, marine spatial planning, integrated environmental management, and for international reporting such as on the SDGs, the Biodiversity Targets, the Paris Agreement on Climate Change and monitoring the progress on key aspects of the blue economy following the COP26 meetings. Also, Ocean Accounts are a key priority of the High-Level Panel on Sustainable Ocean Economy, of which Fiji is a member. The core aspirations of the High-Level Panel are to ensure creation and restoration of additional 30% fully protected marine protected areas, 20% reduction in greenhouse gases, create 12million new jobs by 2030, generate 40 folds more renewable energy, 6 times increase in seafood supply by 2050 and cash a $15.5 trillion net benefits from sustainable Ocean investments.

Ocean accounting is relevant for meeting Fiji's international commitments on Ocean and blue economy (Fiji's Ocean commitments), which aims at enhancing sustainable socio-economic development and environmental protection in marine and coastal areas and islands. The implications of COP26 resolution for Fiji implies that Fiji must ensure ecological balance and harmonize the linkages between conservation and economic development. It also sets targets to key priority sectors such as sea and island tourism, maritime economy, petrol and other resource exploitation, aquaculture, shipbuilding industry, and renewable energy.

Current Ocean Accounting activities within Fiji

The need for Ocean Accounting has led to the formation of National Ocean Policy Steering Committee in Fiji[1] which is working with the UN-ESCAP on developing initial Ocean Accounts. While this is a positive development for Fiji, support from international agencies and development partners on various aspects of Ocean Accounting (developing national statistical frameworks, ecosystems accounting, national marine asset valuation, technical assistance on developing full-fledged Ocean accounts, protection of coastal and marine ecosystems including the use of blue bonds) are important. This GOAP Fiji Pilot is therefore a useful contribution to Fiji. The Fiji pilot intends to draw from and complement existing initiatives on Ocean management in Fiji. This duality is important because of the uncharted nature of Ocean Accounts development in Fiji or in most other countries in the Pacific.

The NOP notes existing and useful initiatives for Ocean and marine resource management, together with the main policy priorities. This policy document is the key reference on Fiji's Ocean policy and plans. It includes Fiji's Ocean policy, climate related issues[2] and management of Ocean resources along the lines of equity, sustainability and economy. It dictates the pathway for strengthening sectoral policies and legislations based on the identified gaps, past experiences of policy implementations, and international practices and global commitments. The NOP is also expected to steer relevant stakeholder coordination and national programs dealing with Oceans. Given the dependence of Fiji's population on Ocean resources, and the risks such resources have been exposed to, the Fijian Government has been at the forefront of domestic as well as international discussions on sustainable Oceans. It continues to innovate policies and legislations; and is implementing initiatives to protect and promote the blue

[1] The National Ocean Policy Steering Committee comprises inter-ministerial representatives of the Fiji Government and subsidiary working groups with defined tasks and associated protocols. At present, it is not practically active, except with the UNESCAP.

[2] Specific climate related policy objectives are in the National Climate Change Policy.

economy. The NOP intends to create sustainable opportunities and bring prosperity and equity to current and future generations of Fijians. Through this policy, the Government intends to support, synergise, promote and establish best practices and standards for Oceans management. The policy therefore charts the direction for strengthening the sectoral policies and legislations based on identified gaps, lessons learnt, evolving international practices, and international developments and commitments. The Fijian Government has championed inclusion of the Ocean agenda during its 23rd Presidency of the UN's Framework Convention on Climate Change through Oceans Pathway Partnership. It has also committed to 100% sustainable management of Fiji's Ocean and designate 30% marine protected areas by 2030. Fiji has also made a strong representation in clarifying its aspirations regarding the blue economy in COP26.

1.2. Scoping the Fiji Ocean Accounting pilot

Given the nature of work, availability of data and the national priorities of Fiji, the context for Ocean Accounting (generally, beyond Mangrove accounts) in Fiji are provided below:

Quality and reliability of data

The National Statistical Office (henceforth 'Fiji Bureau of Statistics', FBOS) does not have detailed methods guidance or data required for constructing Ocean Accounts or its relevant components[3]. There is currently limited capacity within FBOS to develop Ocean Accounts or satellite components. The Fiji pilot will depend on existing, but limited, administrative records, estimates from past studies, and international datasets, where applicable. Remote sensing and dedicated field surveys could help truth the available data, adding value. Some potentially useful datasets for this pilot are fish stock, natural resources, and elements of environment data available with relevant Ministries and the FBOS.

Target outputs

Given that Ocean Accounts are a novel concept to Fiji, and data are limited, the Fiji pilot should consider focusing on one ecosystem type (e.g., mangroves) and later expand to other ecosystems. Mangroves were chosen, due to their importance as an Ocean Asset that Fiji endeavours to preserve under its conservation plans. Data are relatively high-quality and available. Detailed Ocean Accounts can be developed later, possibly in conjunction with UNESCAP. The ecosystems accounts will provide useful information for the detailed Ocean Accounts as well.

Logistics

There are ongoing discussions and collaborations with relevant agencies of the government and other research organizations/agents (SPC and SPREP, for example). This will bridge the slow processes of data generation, advocacy and vetting of project reports.

[3] The Fiji Bureau of Statistics has experience with a few elements of SEEA (waste, water and energy) accounts, which are limited in relation to Ocean Accounts. Some useful dataset include data on subsistence and informal fishing and aquaculture GVA, population GIS maps, key tourism statistics and tourism satellite account.

Connecting to policy objectives

Ocean accounting must directly relate to and support the aspirations of Fiji's Ocean Policy. The Fiji pilot project intends to connect directly to 5 of the 7 goals (details later) of Fiji's NOP. Therefore, this project intends to provide tangible benefits to national initiatives and programs concerning Oceans.

Other spillovers

An interesting segment of ocean accounting is remote sensing of mangroves with greater dimension of indicators and data points. Additionally, an economic estimation of ecosystems benefits will be provided[4] to assist the Government create further incentives for coastal protection and economic empowerment of Fijians dependent on Ocean resources. Beside these, some of the key indicators relevant to developing the Ocean accounts that can be derived from the Fiji pilot are (but not be limited to): changes in mangroves extent and cover, impact assessments of these changes on stocks of marine resources (economical/non-economical) but valuable to Fiji, economic valuation of mangroves and its possible benefits to the national income. These can (in work to follow) stretch to other ecosystems (seagrasses, salt marshes, corals); and the services Fiji's derives from such ecosystems. A roadmap of what Fiji should do and prioritize in its Ocean policy and Ocean accounts development exercise (including the use of Blue Bonds) will also be produced as part of the Fiji pilot.

Key Stakeholders

The project will benefit from consulting the following government agencies and organizations: Ministry of Economy, Ministry of Rural and Maritime Development, Ministry of Fisheries, Ministry of Waterways and Environment, Maritime Safety Authority of Fiji, Fiji Bureau of Statistics, National Disaster Management Office, Fiji Meteorological Service, Ministry of Lands and Mineral Resources, Ministry of i-Taukei Affairs, Locally Managed Marine Area Network; and the Pacific Regional Environmental Program and the Secretariat of the Pacific Community; and other possible local community groups.

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[4] A chapter of the NOP identifies some previous estimates of Fiji's marine ecosystems value (of about US1.2b in 2014), but does note the limitations of undervaluation due to accounted domestic use. The current project is targeted to bridge such gaps.

1.3. Key Objectives of the Fiji Pilot

In support of Fiji's policy priorities and in addressing the stated concerns, key objectives of the Fiji Ocean Accounts pilot are presented in Table 1.1 and aligned with NOP goals. The NOP goals include cooperation (goal 1), sustainability (goal 2), security (goal 3), people (goal 4), development (goal 5) and knowledge (goal 6).

Table 1.1. Description of Ocean Accounting pilot aims and alignment with Fiji's National Ocean Policy (NOP).

Aim	Description	NOP aims
1	Strengthen Fiji's capacity to better account for its Ocean resources (mangroves and other biotic and abiotic marine resources). This supports the Government's priority to mitigate immediate threats to incomes and livelihoods of local communities due to climate change effects.	1, 2, 3, 4 & 5
2	Develop information on a range of Ocean ecosystem services (starting with those of mangrove ecosystems) to assist Ocean Accounting in Fiji.	1, 3, 4 & 5
3	Promote development and/or adoption of better technologies and assessment tools for dealing with biodiversity losses, pollution and destruction of marine ecosystems and unsustainable use of marine resources.	4 & 5
4	Assist Fiji with development of evidence-based policies, legislative mechanisms, and advanced monitoring platforms.	2, 3, 4, 5 & 6
5	Provide an outline of available or potential data sources for constructing mangroves accounts in Fiji and highlight the current limitations to creating an ocean account for mangroves in Fiji.	6
6	Provide recommendations for improving the quality of accounts and scaling nationally.	6

2. Mangrove Accounting

2.1. Mangroves and their importance to Fiji

Mangroves are a group of shrubs and trees that tolerate saline or brackish water, living in coastal intertidal zones of sheltered coastlines within tropical and subtropical climates (30°S – 30°N). Mangroves can thrive in dynamic and harsh conditions inhabiting a harsh and dynamic intertidal environment (between land and the sea), due to their ability to remove salt and complex root systems, which enable them to withstand tidal and wave action. They are subject to daily changes in tidal conditions (which changes temperature, salinity, and nutrient levels) making them robust and highly adaptable. Other factors controlling the distribution of mangroves include sea level, temperature, rainfall and atmospheric CO_2 (Alongi, 2008; McKee et al., 2007; Woodroffe, 1990).

There are twenty-eight genera of mangroves, where each genus is adapted to specific environmental conditions that define their distribution. The global distribution of mangrove forests is largely influenced by temperature. In recent years, distribution has been influenced by the increase in mean surface temperature of 1.5°C, relative to the pre-industrial period (Hoegh-Guldberg et al., 2018), causing shifts to the structure and distribution of mangroves globally, with some advancing to colder climates (Sturm et al., 2001). The most diverse mangroves occur in South Asia (e.g., India, Philippines, and Vietnam), although several genera are found in the South Pacific.

Mangrove forests provide a variety of goods and services that benefit coastal communities. For example, mangroves provide habitat for many exploited species that are important for commercial and traditional fisheries. Further, mangroves stabilise shorelines and protect infrastructure by reducing wind and wave energy and the impacts of storms and floods. There is also a rapidly growing appreciation for their ability to capture and store nutrients, including carbon, which is important in regulating the environment and climate (Barbier et al., 2011; Donato et al., 2011; Friess et al., 2016). The world's largest remaining natural mangrove ecosystem, the Sundarbans (10,017 km^2), alone supports the livelihood of about 4.5 million people in Bangladesh and India (Sarker et al., 2019). They are fundamentally important in providing protection against cyclones and tidal surges, and acts as a haven for many globally endangered plant and animal species to some of the most vulnerable coastal communities.

Fiji has some of the largest mangrove areas in the southwestern Pacific Ocean. Similar to other mangrove forests globally, mangroves are found in riverine, estuarine and sheltered low energy coasts. Fiji has seven mangrove species and one hybrid, categorized into three functional groups depending on growth habits. They are commonly known as red mangroves (local name “tiri”) and black mangroves (local name “dogo”), of the mangrove species *Rhizophora spp*. and *Bruguiera spp*. and white mangroves (Table 1).

Red mangrove is a coastal fringing plant that grows at the water’s edge, with “prop” roots that stabilize trees in soft mud and tidal zones. The name of red mangrove comes from the colour of the sap. Black mangroves have black fruits and seeds and have traditionally been used in dyes usually occur behind red mangroves, in muddy soils that are inundated when the tide is high. They can either have “prop” or “elbow” roots that stick out of the mud. White mangroves can tolerate high salt environments. The high salt concentrations in the plants gives the underside of the leaves white colour, hence the name white mangroves. They grow at higher elevations on dry land immediately behind the red/black mangroves that are not regularly inundated by seawater.

Table 2.1. Overview of mangrove genera within Fiji.

Genera / Species	Local name	Commonly found environments
Rhizophora	Red mangrove	Coastal fringing mangrove growing at the water’s edge.
Bruguiera	Black mangrove	Found behind red mangroves, in muddy substrate that is inundated at high tide.
Lumnitzera Heritiera Excoecaria Xylocarpus	White mangrove	Found immediately behind the red/black mangroves on dry land that is not regularly inundated by seawater.

Between 2001 and 2018, Fiji’s mangrove forest was estimated to be 65,243 ha, with 0.11% annual rate of loss, 77% of which were due to tropical cyclones, whereby the highest losses were identified along the northern coastlines of Viti Levu and Vanua Levu (Cameron et al., 2021). This is consistent with what we find using more rencet data. Mangroves are influenced by land-use activities in waterways and therefore, decisions made upstream have an important implication on the management of mangroves and coastal communities that depend on them (Lal, 2003).

Mangroves have been increasingly recognised in climate change mitigation and adaptation policies across the many island nations in the Oceania, particularly in the context of the impacts of sea-level rise on coastal communities. The Fijian Government, together with other nations in the region, recognises the need to conserve, protect and sustainably manage mangroves, and account for the ecosystem service values of mangroves in national climate strategies and mechanisms in Fiji’s Low Emission Development Strategy 2018–2050 (Ministry of Economy, 2018).

The loss of mangroves, particularly due to climate-induced sea-level rise, reinforces the importance of assessing the value of mangroves and managing them appropriately in coastal management and planning. As climate change continues to intensify, there is an urgent need for the proper evaluation of coastal wetland services. This will require effective regional legislative and local-level planning measures to explicitly recognise their services within policy and legislation.

Importance to Fiji's Ocean economy

Mangroves provide natural resources that benefit several activities of Fiji's economy. Using classifications from National Accounts, mangroves may support activities from the forestry and logging, fishing, manufacturing, construction, water supply and remediation services, accommodation, professional, scientific, and technical activities and arts, entertainment, and recreational activities (refer to the report on "Economic Valuation of Mangroves in Fiji"). The goods and services provided by mangroves could be considered in terms of direct and indirect flows.

Direct flows and benefits

Following the Ocean Accounting Technical Guidance (GOAP 2021) direct flows and benefits could be considered 'used' by industries that are directly using goods derived from mangroves (e.g., wood, and non-wood forest products), using mangrove products as an intermediate input into industry activities or perform activities spatially intersecting within mangrove ecosystems. Mangroves produce wood products that may be used for fuel and construction and may therefore be related to forestry and logging, construction, and manufacturing industries. Mangroves also produce non-wood forestry products that may be used in textiles and traditional crafts. Formal and informal accommodation and tourism activities could also be related to mangroves, performing activities that spatially intersect with the ecosystem.

Indirect flows and benefits

Aside from direct use, mangroves provide several ecosystem services that benefit the health and wellbeing of coastal communities, economic and other human activities, without providing goods directly nor providing services to activities that operate spatially within the ecosystem. These include the enhancement of commercial fish stocks ('fisheries enhancement'), regulation of shorelines (and protection of adjacent infrastructure and housing), regulation of water and climate, and providing cultural services of importance to coastal communities.

The complex root structure of mangroves may serve as habitat to several exploited invertebrate and fish species that are protected from predation and/or rely on mangrove biomass for sustenance. Whilst not directly contributing ecosystem services to commercial fisheries, mangroves increase the stock of exploited species by providing habitat for juveniles, which may then leave to marine (open ocean) waters in their adult phase. Mangroves effectively increase the 'efficiency' of production (Anneboina and Kumar, 2017) by increasing the potential stock of exploited species without requiring further inputs to the production of these species, relative to if mangroves were absent. Several exploited species important to Fijian marine fisheries rely on mangroves at some stage of their life cycle.

There is also a growing appreciation of the role mangroves play in regulating climate and water quality. Mangroves play a vital role in the cycling and regulation of carbon, nitrogen and phosphorus within coastal systems (Berg *et al.*, 2016), sequestering these nutrients from the water column into their biomass (i.e., stock), which then may be transferred into the soil and subsequently buried into long-term storage over time (i.e., flow). This may act as a significant sink for carbon, mitigating the impacts of climate change. The capture of nutrients may improve water quality, that may otherwise algal growth and eutrophication (Berg *et al.*, 2016). The sequestration and capture of carbon is a policy focus of Fiji's National Ocean Policy.

Another service provided by mangroves is the ability to reduce the impact of wind and wave energy, flooding, and tidal surges during storm events through sediment stabilisation and providing a physical barrier along coastal and riverine environments. As a potential 'nature-based solution', mangroves can reduce the damage imposed on coastal infrastructure and households from storm events. As Fiji is frequently at risk of wind and wave damage from tropical cyclones and storms, mangroves play a key role in reducing risk to these built assets.

Mangroves are also of cultural significance to coastal communities, embedded in cultural practices, art, stories and the history of Fiji. In terms of use, women also play a significant role in the sustainability of mangrove forests in the Pacific and region and are known as caretakers of mangroves as they are access and utilise their resources on a regular basis (food, timber, fibre), and hold knowledge and experience of the changes in mangrove ecosystems for generations. There is an urgent need to incorporate gender into ecosystem-service valuation and management interventions as this will produce sustainable and equitable livelihood outcomes (Pearson et al., 2019).

Accounting for mangroves ecosystems

An accounting framework (see Figure 1.2) structures ocean ecosystems into assets, of a particular size (i.e., extent) and type (e.g., corals, mangroves, seagrass) of a condition, based on reference conditions or other indicators. These ecosystems are responsible for the production of goods and services (henceforth ‘ecosystem services’, such as raw materials, protecting coastlines, a place for recreation), that benefit human health and wellbeing, through their use by individuals, businesses, government, household, or community.

Therefore, decision makers may monitor policies and management interventions, which may impact the extent of ecosystems and the flow of services. For services that are not easily (nor should be) valued in monetary terms, accounts may be presented in physical (e.g., litres, hectares) and monetary units. A set of accounts, maintained over time, may then be used to monitor the condition and sustainability of the ecosystem over time, allowing for informed management, and evidence-based decision making (Figure 1.2).

Figure 2.1. The role of mangroves in coastal protection from wind and wave energy, particularly during storm events. Adapted from World Bank and Punto Aparte.

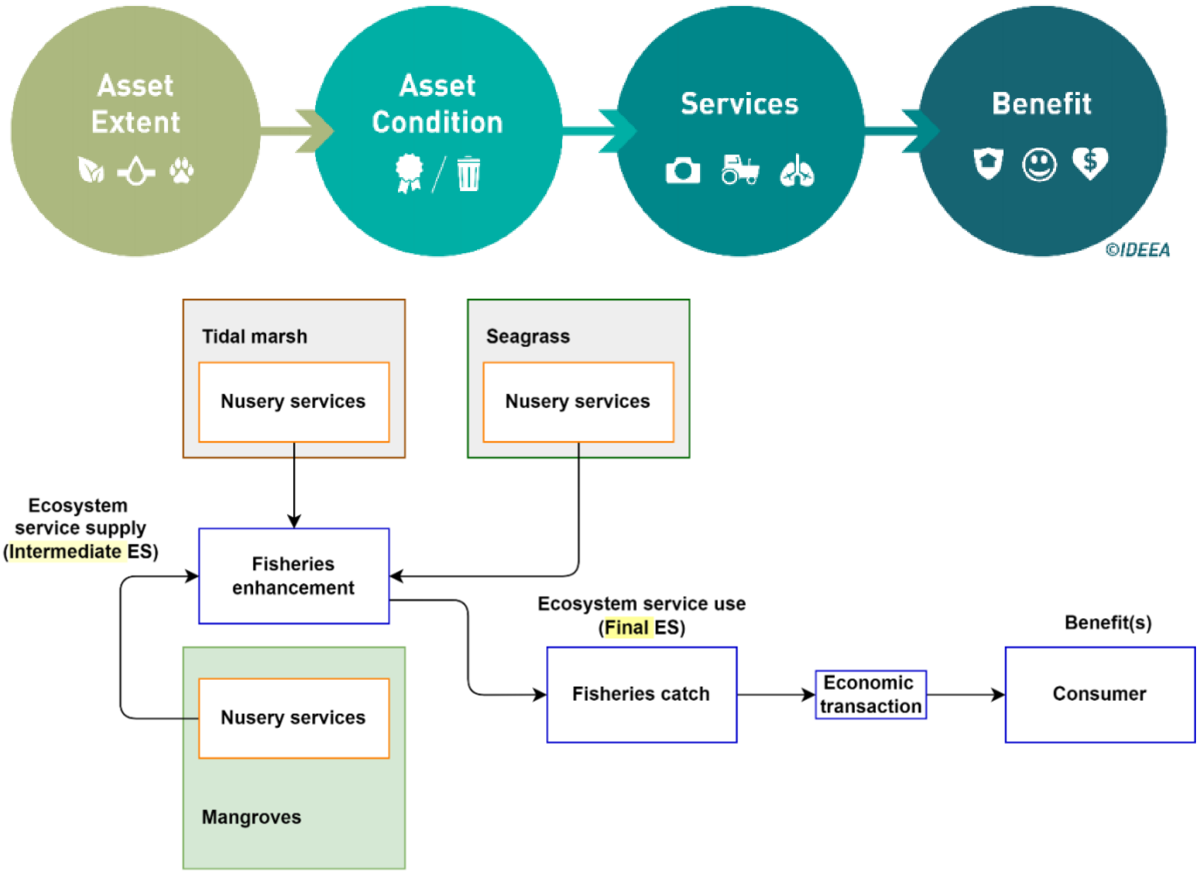

Figure 2.2. (Above) Core ecosystem accounting framework, adapted from Eigenraam and Obst, (2018) and IDEEA group (2020). (Below) An example of the Ocean ecosystem and the services and benefits it provides. The flows follow from assets (mangroves, seagrass and tidal marsh) to ecosystem service supply (or 'intermediate services', nursery services), ecosystem service use (or 'final ecosystem services', fisheries), to the consumer (benefit). Adapted from IDEEA group (2020).

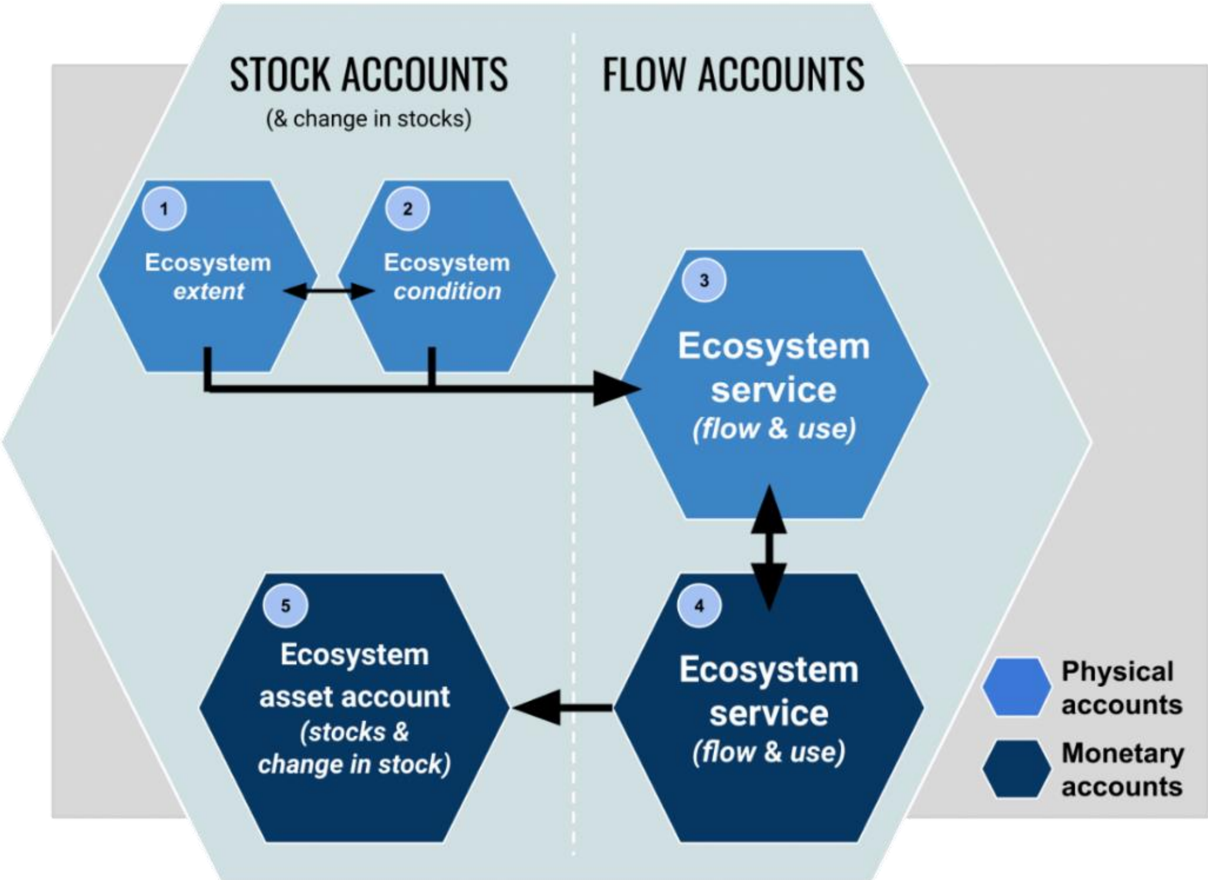

Figure 2.3. Ecosystem accounting framework (from SEEA-EA, 2012). Note that the accounts stem from physical measures of the environment.

2.2. Ecosystem Accounting Methodology

Data availability for mangroves accounts

Mangroves ecosystems can be considered environmental assets, defined by the SEEA as “spatial areas comprising a combination of biotic and abiotic components and other characteristics that function together...” (United Nations, 2014). Comprehensive environmental-economic accounts require data sets with adequate spatial and temporal resolution, to capture the inherent variability within the environment and trends in ecological change.

Data on the extent and condition of mangroves is available for Fiji, with coverage and quality developing rapidly within the last decade. In 2018, the Global Mangrove Watch Initiative released a new global baseline which estimates the total mangrove forest area of the world as of 2010 at 137,600 km^2 (53,100 sq mi), spanning 118 countries and territories (see Section 3.2 for Fiji). Other global initiatives map mangrove extent as part of natural forest assessments and change in global forest cover. Few datasets, however, possess the temporal resolution needed to maintain extent and condition accounts, and few examples exist of further relating these accounts to flows to the economy and society.

Section 2 explores the ideal data and indicators to compile mangrove accounts, in addition to approaches to overcome data gaps and identifies priority areas and knowledge gaps. Here we explore the methodology for elements of ecosystem extent and condition.

Mangrove extent

Environmental parameters influencing distribution

The mangrove area in Fiji has been estimated at 65,243 ha in 2018 by Cameron et al. (2021), through a project initiated by Conservation International and the Australian Federal Government. Within the Melanesian region of Oceania, Fiji has the third-largest mangrove area, after Papua New Guinea and the Solomon Islands. The largest mangrove populations are found in riverine/estuarine deltas and sheltered low energy wave shores along the south-eastern and north-western coasts of Fiji, the largest of which are found in the Ba, Tuva and Rewa deltas (Fig. 2.4).

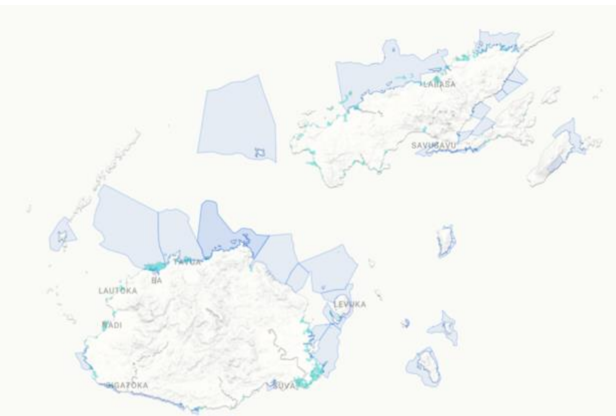

Figure 2.4. Distribution of mangroves throughout Fiji, focusing on Viti Levu and Vanua Levu. Source: Global Mangrove Watch (https://www.globalmangrovewatch.org/)

Habitat classification

There has been some inconsistency in the reporting of the total area of mangrove habitat for Fiji. For instance, a report by the Worldwide Fund for Nature (WWF) South Pacific Program estimated the total mangrove area in Fiji to be 51,700 ha in the mid-1990s (Ellison, 2010), whilst the Global Mangrove Watch estimated an area of 50,873 ha of mangroves in 2016. These discrepancies are associated with using different techniques for quantifying the spatial extent of mangroves forests, which can be a challenging process due to lack of information and data points. Hence, there is a need to use standardised data and methodologies to account for accurate mangrove cover, which will be valuable in assessing the status of mangroves and investigate spatial and temporal variation in mangrove distribution in relation to climate change in the region.

As described above, extent is predominantly mapped using satellite imagery, which is trained via visual inspection (supervised) and more recently, through machine learning. Higher resolution surveys have been conducted using aerial imagery and on-ground surveying, although with more limited spatial and temporal resolution. Each survey method has given strengths and weaknesses, and none are most appropriate for mapping all mangroves habitat in Fiji (Table 2.2).

Table 2.2. Overview of the techniques used to record the extent and condition of mangroves.

Measurement technique	Units	Pros	Cons
Aerial imagery	Area (m^2, Ha, Km^2)	- Covers large spatial scale	- Potentially low spatial resolution - No associated biodiversity or density data - Significant expertise required to process images.
Satellite imagery	Area (m^2, Ha, Km^2)	- Covers large spatial scale	- Errors produced by classification of cells to mangroves - Significant expertise required to process images.
On-ground surveys	Area, percent cover, density	- Highly accurate - Can obtain biodiversity and density data. - Low training to process	- Limited spatial and temporal coverage.

Mangrove condition

The distribution of mangrove species depends on site-specific environmental (physical), chemical and biological conditions. These conditions are collectively referred to as ecosystem conditions. Generally, ecosystem condition is used to describe the state of an ecosystem, and as such, ecosystem condition is represented in different ways (O'Brien et al., 2016). Physical indicators are related to substrate composition, primary habitat indicators (density, height, biomass), proximity to disturbance factors, or environmental variables (e.g., temperature, wave current). Chemical indicators relate to contaminant levels in water, nutrient loads, primary production (chlorophyll), and physicochemical parameters (e.g., salinity, pH). Lastly, biological indicators refers to the biodiversity in the ecosystem, either at the community, individual, or population level (O'Brien et al., 2016).

Table 2.3. Measures of the condition (state and pressures) on mangroves ecosystems.

Condition	Environmental indicators
State	- Measures of density - Measures of biomass - Measures of Percent cover - Chemical composition - Biodiversity - Growth rate
Pressures	- Tropical cyclones - Land clearing / urbanisation - Eutrophication

Mangrove Pressures

Several pressures influence the extent and condition of mangroves, from anthropogenic and natural sources. Anthropogenic pressures include climate change, urbanisation and coastal development, and nutrient run-off. Natural sources of pressure include tropical cyclones.

Climate change is expected to impose a global impact on mangrove ecosystems. Some of these impacts include, but are not limited to, rise in sea surface temperatures, decrease in precipitation, sea-level rise, increase in atmospheric CO_2, and an increase in the frequency and severity of extreme weather events. Whilst resilient to significant changes in daily environmental conditions (e.g., changes to salinity and temperature), mangrove species within Fiji may not be able to tolerate the increased frequency of severe storms, rainfall and sea-level rise.

Mangroves have the ability to adapt to sea-level changes, which they can do by either moving laterally or vertically by the accumulation of mangrove organic matter and trapping sediments (McKee et al., 2007; C.D. Woodroffe et al., 2016). In some locations, however, landward retreat of mangroves may be limited because of natural and human barriers, whilst vertical growth is limited by low sediment availability. A decline in sediment inputs can be associated with instream barriers (e.g., dams and weirs) that can inhibit the transportation of sediments from rivers and streams into estuaries occupied by mangroves.

Urbanisation has also led to wide-spread mangrove clearing, to provide space for housing and built infrastructure. Over the last quarter-century, Caribbean mangroves have declined by approximately 24%, largely as a result of anthropogenic impacts, including coastal development, pollution, and human exploitation (Wilson, 2017). Other human activities such as overfishing, dredging, pollution and reclamation has also resulted in the depletion of both mangroves and coral reef populations (Ellison, 2010).

Tropical cyclones have been reported to have caused considerable damage to mangroves forests in northern coastlines of Viti Levu and Vanua Levu (the two largest Islands in the Fiji archipelago) (Cameron et al., 2021). Tropical cyclones accounted for about 77% loss in mangrove areas between 2001 and 2018 (total loss was estimated at 1135 ha). The level of damage from the cyclones was variable between different mangrove types, with coastal fringing or scrub mangroves sustaining less damage than taller riverine and hinterland vegetation.

Of key consideration is the feedback between different ecosystems. In the tropics and subtropics, coral reefs tend to provide significant protection to mangrove plants from waves and storm surges. The anticipated climatic pressures of sea level rise, decreasing rainfall, and an increase in extreme weather conditions will have an impact on coral reefs, which is expected to cause significant decline in mangrove forests, and affect the many ecosystem services and economic value that mangroves provide to coastal communities.

2.3. Fiji mangrove account pilot (preliminary results)

A scoping study identified the utility of mangrove ecosystem accounts in furthering Fiji's National Ocean Policy and capacity for environmental-economic accounting. A desktop study was conducted, limited to available open-source data. The following section presents the strategy and preliminary results of ecosystem extent and condition account compilation.

Framework overview and account compilation strategy

Ocean accounts extend existing accounting standards, where the present study draws upon SEEA-EA and the Ocean Accounting Technical Guidance (GOAP, 2021), with Table 2.4 presenting the definitions used for this study.

Account compilation strategy

Following the Ocean Accounts Framework (GOAP, 2021) and SEEA-EA (UN, 2017) account construction followed the following steps:

- Scoping of use-cases of mangrove accounts to inform coastal management,
- Establish a basic spatial unit (BSU) and grid for Fijian space, focusing on the coast.
- Compilation of a data inventory, literature review and shortlist of key contacts for Fiji,
- Note that relevant ecosystem services are not included in this report.
- Construction of an ecosystem extent and condition accounts.

Basic Spatial Unit and Grid

To align mangrove extent and condition, a grid was produced for the entire Fiji, including land, territorial waters, and exclusive economic zone. In considering computing power and the resolution of datasets, a 1 km^2 grid size was chosen as the 'basic spatial unit' (UN, 2017) or the unit of measuremnt in our analysis. As mangroves are predominantly in coastal areas, a subset of the grid (henceforth 'coastal grid') was made in selecting grids within 1 km of the Fijian shoreline. Each unit of the coastal grid was then assigned to an administrative area, as one of fourteen provinces within Fiji. Coastal grids were assigned through intersections (i.e., physically within the administrative area). For coastal grids that did not intersect with an administrative area, the closest area by distance to the shoreline was assigned.

Table 2.4. Definitions of terms used within the study, as used within the Ocean Accounting Framework (GOAP, 2021), and aligned with SEEA-EA (UNSD, 2021) and SNA (UN, 2008) statistical accounting standards.

Term	Definition	Example
Ecosystem	A contiguous space of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions.	Mangrove, tidal marsh, seagrass
Basic Spatial Unit	The subdivision of the accounting area spatially to align data.	The present study uses a 1 km^2 square grid (see Figure 1).
Ecosystem extent	The range and extent of ecosystems within an accounting area. Ocean Accounts endorses the use of the IUCN Global Ecosystem Typology (Keith *et al.*, 2020).	Landcover of mangroves (in hectares).
Ecosystem condition	The quality of an ecosystem measured in abiotic and biotic characteristics. Note that there are no standardised indicators for each ecosystem, although the SEEA-EA provides guidance for the development of condition accounts.	Mangrove tree height, above ground biomass.
Ecosystem services	The contributions of ecosystems to the benefits that are used in economic and other human activity. Services are categorised broadly into provisioning, regulating and cultural services. Services are measured either as a good or intangible product of the system.	Commercial fisheries enhancement (provisioning service)
Ocean-related sectors	Sectors with spatial intersection or dependent on ocean resources, including activities that use ocean resources as an input (e.g., fishing), and produce products and services for use in the ocean environment (e.g., shipbuilding).	Coastal and marine fishing, water transport (coastal and marine), shipping and ports.
Ocean economy satellite accounts	Accounts that measure economic activity dependent on oceans, including activities that use ocean resources as an input (e.g., fishing), produce products and services for use in the ocean environment (e.g., shipbuilding), or use ocean space due to geographic proximity (e.g., warehouses that service ports).	Production, employment accounts for ocean-related sectors.

Ecosystem extent

Fijian mangroves belong predominantly to the genera *Rhizophora spp.* (*R. selala, R. Stylosa*) and *Bruguiera spp.* (*B. gymnorrhiza*), across coastal, deltaic, and riverine environments. The extent of mangroves was determined using open-source datasets, described in Table 2.5.

Table 2.5. Mangrove datasets accessed and assessed for this study.

Dataset name	Description	Data owners	Time series	Link
SPC / GIZ Mangrove mapping	Layer generated by supervised classification, aided by digitization of training samples, and corrected by visual interpretation and available ground collected data.	SPC-GIZ exercise with the assistance from the Forestry Department Fiji.	2016	pacgeo.org/layers/geonode:lakeba_mangrove
Global Forest Change	MODIS and Landsat imagery were used to establish a Global Forest Monitoring Capability Using Multi-Resolution and Multi-Temporal Remotely Sensed Data Sets.	NASA / University of Maryland	2013, 2015 - 2020	lcluc.umd.edu/metadata/global-forest-change
Global Mangrove change data	Global change in extent of mangroves for select years from 1996 to 2016, using Landsat and ALOS imagery.	Aberystwyth University and soloEO	1996, 2007 - 2010, 2015, 2016	data.unep-wcmc.org/datasets/45

The quality (accuracy) of each data source was assessed using aerial imagery, focusing on:

- the alignment of mangroves with water bodies (using the Fiji land area),
- whether mangroves were confounded with neighbouring forests.

After initial assessment, the Global Mangrove Watch (GMW) database was chosen due to time series (several available years) and more accurate data coverage, relative to the other two data sources. The GIZ / SPC mangrove layer could be used in the future but requires further correction and truthing with collected ground data and aerial imagery. The Global Forest Change dataset was not used, as further work would be required to determine mangrove from other forest areas.

After the GMW data was chosen, three years were selected to define the accounting periods, namely 2008, 2010 and 2016. The years were chosen based on availability and significant events as tropical cyclones, known to impact mangrove extent.

For each year the spatial data was:

i. Converted from raster to polygon,
ii. Projected to WGS84, to align with the Basic Spatial Unit grid,
iii. Clipped by the outlines of the grid,
iv. Area for each calculated mangrove patch calculated and summed per grid.

The density of mangroves was mapped for 10 provinces, with the grids were then aggregated per provincial administrative area, to calculate the area of mangrove per province. Mangrove density per grid for the two main islands (Viti Levu, Vanua Levu) is presented in Figure 3.2, and coverage per province (hectares) presented in Table 2.6.

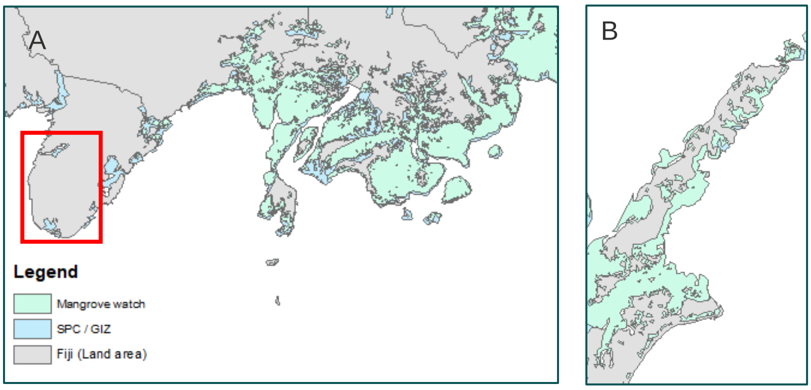

Figure 3.1. An initial assessment of data coverage and resolution for mangrove watch data and SPC/ GIZ mapping, comparing mangroves within (a) the capital city of Suva (red) and (b) comparing coverage to the east of the city, where desity of relatively high.

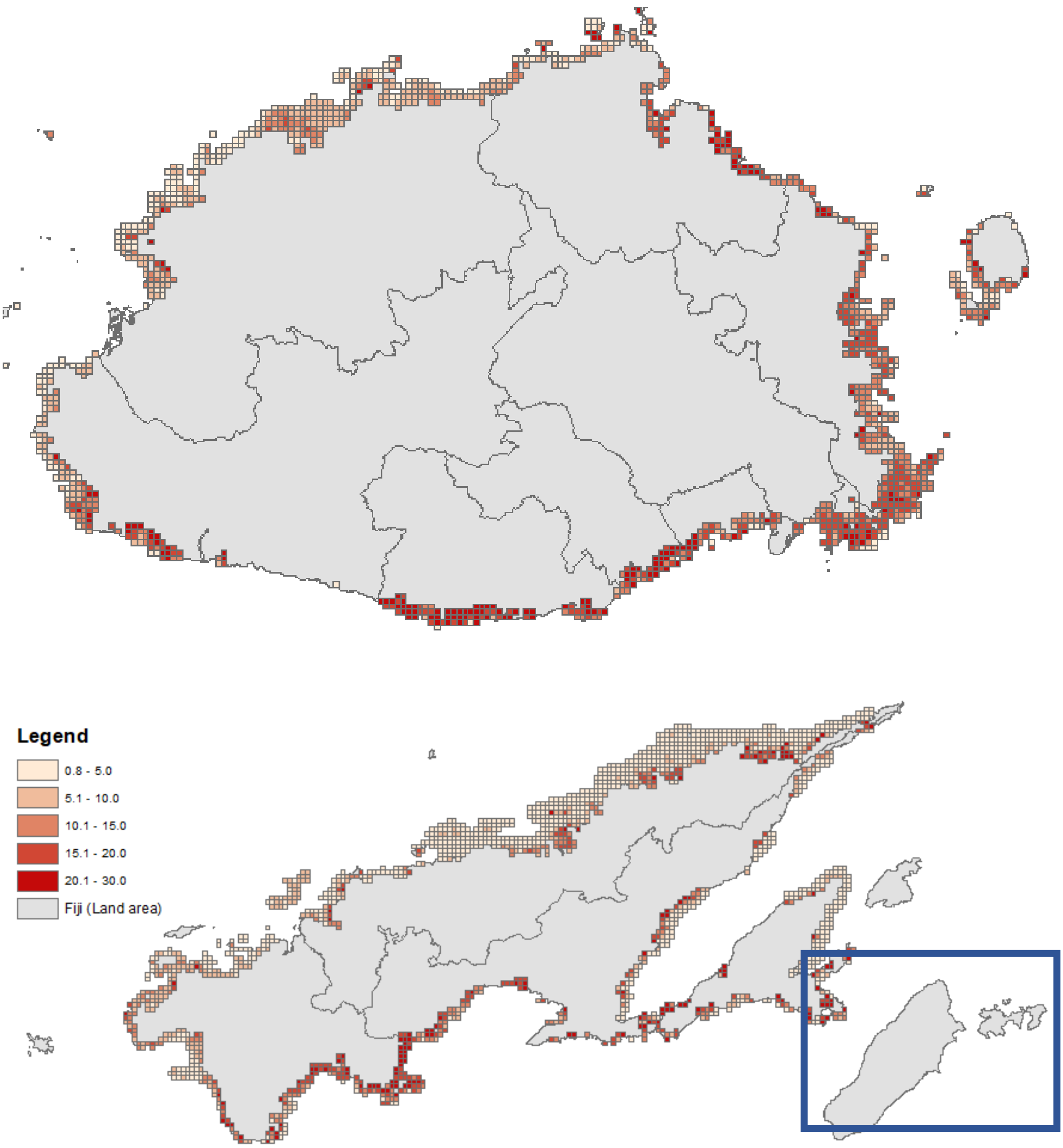

Figure 3.2. Mangrove density per grid for the two main islands (above) Viti Levu, and (below) Vanua Levu). Note that smaller coastal mangroves (< 0.2 ha) were not captured in the spatial analysis (blue box).

Table 2.6. Mangrove extent per 12 provinces within Fiji, for the 2008, 2010 and 2016 accounting periods.

Province	Extent (ha)		
	2008	2010*	2016
Ba	10980	10593	10593
Bua	7968	7931	7931
Cakaudrove	3291	3283	3283
Lomaiviti	916	914	914
Macuata	12303	12305	12305
Nadroga Navosa	2037	2015	2015
Naitasiri	406	405	405
Namosi	531	531	531
Ra	1152	1138	1139
Rewa	3587	3566	3565
Serua	799	796	796
Tailevu	7393	7323	7324
Grand Total	51362	50800	50800

*Data showed marginal change between 2010 and 2016, despite larger natural weather events. Further work is needed to assess accuracy and improve coverage estimates from satellite imagery.

Comparison with other studies

The present accounts observe a 0.9% decrease in mangrove cover (562 ha) between 2008 and 2016. In 2016, the accounts estimated 50800 ha of mangrove cover across the 10 provinces, which differs to previous estimates. Cameron *et al.* (2021b) estimated 65,243 Ha across all 14 provinces of Fiji in 2001, using a combination of Global Forest Change and SPC / GIZ dataset. This suggests that the dataset used for this study (GMW) may underestimate the mangrove extent. Another explanation is the overestimation by Cameron et al. (2021), where extent estimates may be impacted by ‘patchiness’.

A factor that needs to be explored further is the impact of tropical cyclones on remote sensing. The present accounting period intersects with Tropical Cyclone (TC) Evan and TC Winston. TC Evan caused significant flooding and damage to Fiji. TC Winston was the most intense tropical cyclone to make landfall in the southern Hemisphere. TC Winston made landfall in Fiji on 20 February 2016, where sustained 175 km/h winds led to damage to 40,000 homes, impacting 350,000 people on Viti Levu. Mangroves to the northern provinces and adjacent islands of Viti Levu have been impacted, reducing tree height and land cover (Cameron et al. 2021).

Future works should:

- Increase the accuracy of estimates through high-resolution ground truthing of data (drones, in-person surveys).
- Clarify 2016 estimates and how TC affected mangroves are measured (e.g., dead biomass and regrowth).

Ecosystem condition

The Ecosystem Condition Account (or table group) is a key component of the System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) and featured within the Ocean Accounting technical guidance.

The condition account presents statistics and indicators for the general condition or state of an ecosystem and may also be extended to include indicators for pressure that may affect ecosystem functioning (UN, 2017). For Ocean ecosystems state indicators reflect the state or condition of vegetation, biodiversity (or nature value), soil, water, and air. Pressure indicators reflect pressures from pollution and urbanisation. Pressures can affect the condition (or state) of ecosystems and thereby affect the services provided by ecosystems. As the supply of ecosystem services is usually non-linear with ecosystem extent, condition accounts are needed to understand the continued supply into the future. For mangrove accounts, this study focused on three condition variables, with rationale and data sources presented in Table 2.7.

Table 2.7. Condition variables assessed within the study. BSU = Basic Spatial Unit.

Variable	Description	Rationale	Data source
Maximum canopy tree height	Average maximum canopy tree height per BSU.	Tree height is used to model biomass and infer functioning of mangrove forests. Related to carbon sequestration and habitat provisioning.	Simard *et al.* (2019) https://doi.org/10.3334/ORNLDAAC/1665
Basal-weighted tree height	Tree height, weighed by the diameter at chest-height. Average calculated per BSU.		
Above ground biomass	Modelled Above ground biomass, summed per BSU.	Above ground biomass is needed in carbon accounting, to calculate storage in biomass.	
Net primary production (NPP)	Estimate of net primary production per BSU.	Net primary production is needed in carbon accounting, to determine annual increase of storage into biomass. Factors from studies of genera Rhizophora spp. and Brugiera spp..	Min (Sri Lanka) – 8.74 t / ha, (Amarasinghe and Balasubramaniam, 1992) Max (PNG) – 19.5 t / ha, (Robertson, 1991)

Modelled estimates for mangrove condition

On-ground data was not available for this exercise and modelled estimates using existing literature values were used to estimate four condition variables across Fiji. Modelled estimates of maximum and basal-weighted tree height were sourced from Simard et al. (2019) who estimated canopy height and allometric relationships, ground-truthed using 331 plots of mangroves within the tropics. Relationships were then modelled for global and regional allometric models to calculate above-ground biomass from the basal area weighted height. The map of basal area weighted height was derived from ground elevation from the Shuttle Radio Topography Mission (SRTM) (2000) and canopy elevation from ICESat/GLAS spaceborne lidar (2003–2009). Note that the base year was 2000 and the time series was unavailable.

Net primary production (NPP) was calculated using ecosystem ‘factors’ from previous literature of mangroves from the same genera (Rhizophora and Bruguiera). Estimates for Fiji were unavailable and therefore to capture the potential range, minimum and maximum estimates were used from Sri Lanka and Papua New Guinea, respectively. Estimates of tree height and above ground biomass are provided in Figure 3.3, 3.4 and 3.5, and in tabular form in Tables 2.8 and 2.9. NPP is provided in Table 2.10.

Table 2.8. Modelled mangrove average maximum tree height (m) and basal-weight tree height (m), averaged per basic spatial unit within provinces of Fiji.

Province	Mean max canopy height (m)	Mean basal-weighted height (m)
Bua	18.18	11.52
Cakaudrove	9.96	6.31
Macuata	5.36	3.40
Ba	7.90	5.00
Nadroga Navosa	9.76	6.19
Ra	9.22	5.84
Lomaiviti	8.92	5.66
Rewa	13.98	8.86
Serua	21.88	13.86
Tailevu	13.54	8.58

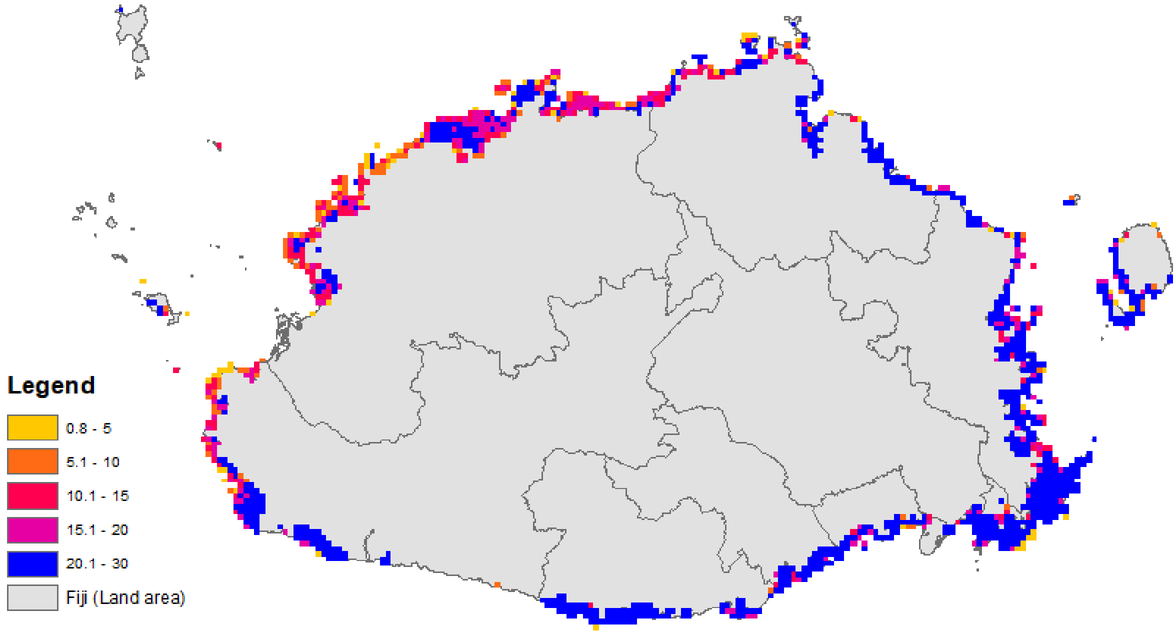

Figure 3.3. Maximum tree canopy height (m) per basic spatial unit for Viti Levu in 2016.

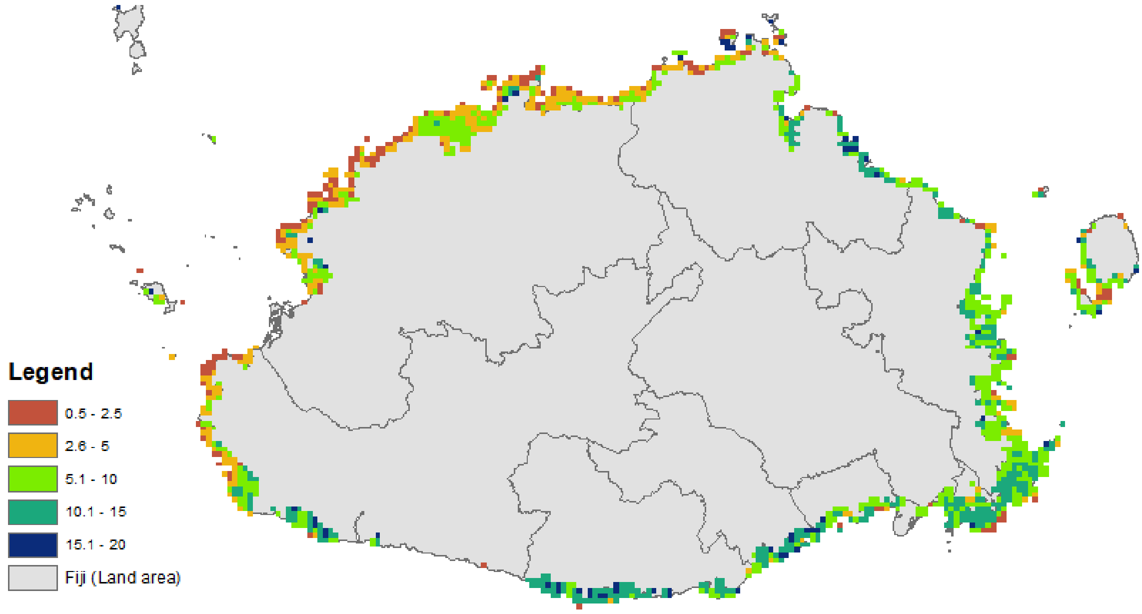

Figure 3.4. Basal weighted tree height (m) per basic spatial unit for Viti Levu in 2016.

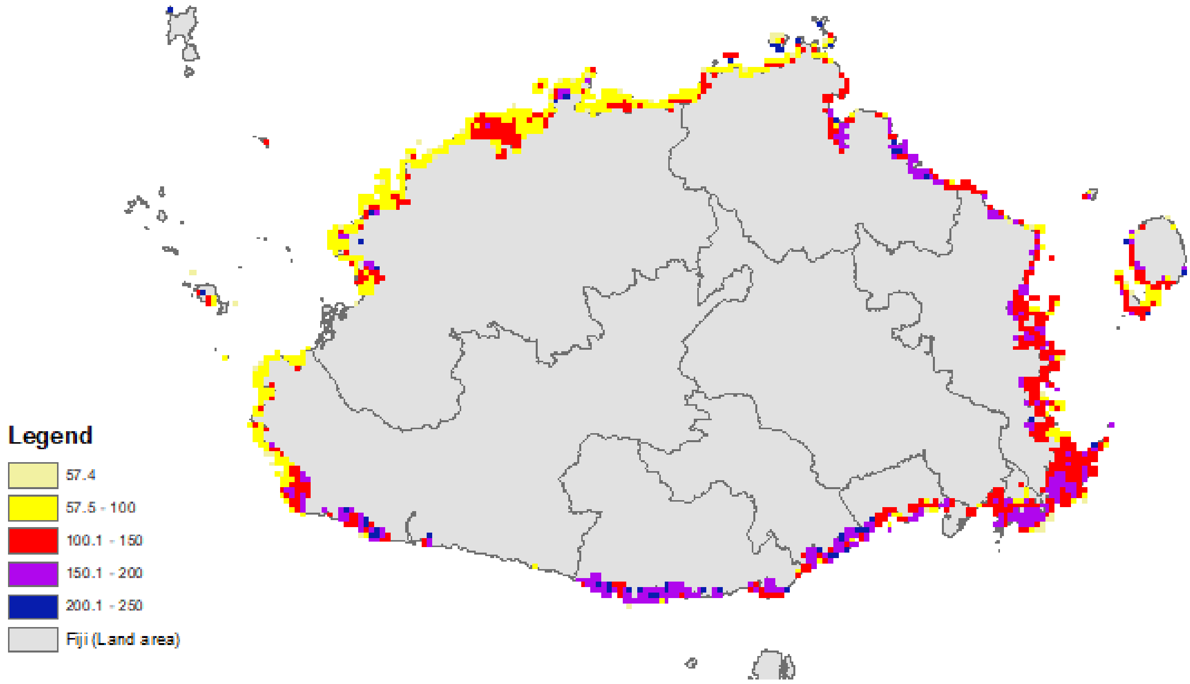

Figure 3.5. Above ground biomass (AGB) per basic spatial unit for Viti Levu (in tons) in 2016.

Table 2.9. Mangrove above ground biomass (AGB) in tons per province in Fiji for 2008, 2010 and 2016.

Province	Above ground biomass (tons)		
	2008	2010	2016
Bua	119901.8	119978.3	119951.4
Cakaudrove	98131.41	98216.8	98224.85
Macuata	656916.5	657251.8	657236
Ba	749192.1	734122.4	734028.1
Nadroga Navosa	65790.46	65562.81	65586.81
Ra	76013.48	74826.4	74886.85
Lomaiviti	74657.25	74507.07	74459.27
Rewa	11113.19	11062.21	11060.27
Serua	62103.7	62104.89	62099.44
Tailevu	191411.5	189141.1	189206.1

Table 2.10. Condition account for Mangrove Net Primary Production (tons/year) per province.

Province	Net primary production (tons / year)					
	2008		2010		2016	
	Mean	SE (±)	Mean	SE (±)	Mean	SE (±)
Bua	10098	6250 - 13945	10105	6255 - 13956	10102	6253 - 13951
Cakaudrove	10973	6792 - 15154	10966	6788 - 15145	10966	6788 - 15144
Macuata	99097	61339 - 136854	99256	61437 - 137074	99272	61447 - 137096
Ba	104791	64863 - 144718	102755	63603 - 141906	102752	63601 - 141902
Nadroga Navosa	9080	5620 - 12540	9046	5599 - 12492	9045	5599 - 12492
Ra	10763	6662 - 14864	10576	6546 - 14606	10586	6553 - 14619
Lomaiviti	10030	6209 - 13852	9999	6189 - 13809	9997	6188 - 13806
Rewa	1063	658 - 1468	1058	655 - 1461	1058	655 - 1461
Serua	4761	2947 - 6575	4762	2947 - 6576	4760	2947 - 6574
Tailevu	20432	12647 - 28217	20196	12501 - 27891	20205	12507 - 27904
Fiji	28109	17399 – 38819	27872	17252 – 38491	27874	17254 - 38495

2.4. Preliminary conclusion (mangrove ecosystem accounts)

Progress towards mangrove ecosystem accounts for Fiji

This exercise identified data sources that could be used to compile mangrove accounts within Fiji, specifically of mangrove extent and condition. Several global datasets exist for both extent and condition, although data quality should be assessed and where possible, improved to maximise the accuracy of estimates. This could include remote sensing techniques such as drones and aerial imagery to complement satellite derived data. Ground-truthed data should also be collected per province to improve extent and condition estimates.

The preliminary extent and condition accounts here provide a means to estimate ecosystem services, which will be the second stage of the accounts. Ecosystem services that should be considered include the enhancement of commercial fisheries, blue carbon (carbon sequestration and capture) and shoreline protection.

Emerging initiatives in support of mangrove ecosystem accounts

Initiatives in support of mangrove ecosystem accounts arise from (1) primary data collection efforts and (2) investment into environmental-economic accounting. Ongoing primary data efforts including the mapping of mangrove ecosystems and their condition. Known stakeholders include the University of the South Pacific, the University of Queensland, South Pacific Community, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Conservation International.

In support of accounting initiatives, the UN Economic Social Commission for Asia and the Pacific (ESCAP) is working with the Fiji Government, with the formation of the National Ocean Policy Steering Committee. Other known stakeholders include the IUCN, Australian Government, the Government of the United Kingdom (UK) and others.

Key recommendations

This section has outlined a methodology and the information available to develop a series of accounts for mangrove ecosystems in Fiji. We applied the described approach to create extent and condition accounts for 10 provinces. While these numbers provide insights into the status of mangroves within each region, there are multiple data deficiencies that limit the confidence in these values. Further work should address these deficiencies, improve the confidence in estimates, and allow for other ocean ecosystems within Fiji.

We suggest the following actions are prioritised:

1) Increase the resolution and accuracy of mangrove mapping, incorporating available aerial imagery.
2) Increase the number and geographic spread of ground-truthing locations that record ecosystem extent and condition.
3) Produce a roadmap to assess ecosystem services and their links to Fiji’s ocean economy.

3. Valuation of Mangrove Contributions to the Economy

Background

This chapter explains the methodology and analytical findings of the economic (SNA) and other (non-SNA) contributions of mangroves in Fiji. There are 2 pieces of analysis (i) a macroeconomic study of the SNA benefits of mangroves; and the second is a micro-level analysis of the non-SNA benefits. Both attract different methodologies. While both are important, the findings of the latter are to be viewed in conjunction with those obtained under the SNA impact analysis because of its sampling properties. However, the latter has strong micro-foundations that could provide rich information on non-SNA benefits. These findings inform Fiji's Ocean Policy, providing rationale for why mangroves need to be preserved and protected considering the human activity/demand of the ecosystem services, and the effects of climate related threats on ecosystem services, etc. These analyses are key to developing mangrove satellite accounts which are expected to feed into the Ocean Accounts currently being developed for Fiji. This paper provides scope for further work potentially of great value to Fiji. A detailed longitudinal study involving these ecosystems together could present some real estimates for economic aspects of Ocean Accounts relevant for Fiji's Ocean policy.

This section is structured as follows. Section 3.2 is a survey of relevant literature on economic valuation of mangrove ecosystem accounts followed by an analysis of the SNA benefits in Section 3.3. Section 3.4 discusses these findings considering their implications for Ocean policy and concludes.

3.1. Literature on economic valuation of mangrove ecosystems

Mangroves are an important ocean asset for Fiji on which a significant share of local population in coastal and maritime zones depend on. Fiji has some of the highest mangrove coverage in the south Pacific, several species across coastal, deltaic, and riverine environments. Remote sensing using global datasets estimate the cover in 2018 to be 65,243 Ha, with significant variation within and between islands due to land-use and climate factors (Cameron et al., 2021b). Based on the 2010 baseline FAO estimates, mangrove represents about 6.6% of the total forest cover in Fiji in 2018. A more complete detail of mangrove (extent and cover) is presented in Chapter 2.

One of the key issues about mangroves is its loss and economic valuation. Lal (1990, 2003) claims that this is mainly (86%) due to agriculture and rice farming in Fiji. More recent development in tourism and infrastructure development has added to the loss. Mangrove loss between 2001 and 2018 was estimated at 1135 Ha, where Cameron et al. (2021a) estimates that 77% of loss could be attributed to intense and frequent tropical cyclones (TC Winston on 2016 being the most damaging). The annual decline was estimated at 0.11%. The loss of mangroves in limited areas may have implications for the services it provides, including coastal protection and nurseries for commercially important species (finfish, invertebrates) (Vo et al., 2012). Generally, mangroves provide a wide range of ecosystem services, including nutrient cycling, soil formation, wood production, fish spawning grounds, ecotourism and carbon storage. For Fijians, mangroves are one of the most important Ocean resources.

Direct and indirect uses of mangroves by sector

Based on the Fiji national accounts data of 2017/2018, the direct use value of mangroves constitutes wood, fisheries, construction, transportation and tourism services. Fisheries have the largest use of mangroves as an input. The indirect use value of mangroves ecosystem is in the form of vital ecological functions including control of coastal erosion, stabilization of sediment, protection of adjacent coral reefs from suspended solids, protection of coastal land uses from storms, prevention of salt intrusion, natural purification of coastal water from pollution, supply of organic detritus and nutrients to adjacent coastal waters, and the provision of feeding, nursery and breeding areas for economically important fish, crustaceans and wildlife. While some of these activities do happen and are recorded in Fiji's national accounts (although not records of indirect ones), others are either informal or non-existent. Fijian Government has preserved selected mangrove sites and plans to introduce new ones as well in the future. It has also instituted policies which restrict abuse and destruction of mangroves.

However, oftentimes, the economic contribution of mangroves are under-stated. This may be attributed to two factors (Hamilton *et al.*, 1989): (i) many of the goods and services provided by these ecosystems are not traded on the markets and thus do not have an observable value; and (ii) some of these goods and services occur off-site and are therefore not readily acknowledged as being related to mangrove ecosystems. As a result it is often concluded that mangroves should be developed for uses which generate directly marketable products, such as aquaculture. Empirical studies aspire to determine the total economic value of mangroves, but most are narrower, focusing on is considered to be most important services having market value, can be measured with available data, or are needed for decision-making. No one valuation method is suitable for assessing all ecosystem services; rather, a variety of methods has been used according to service type, available data, and the timeframe of the study (Sarhan and Tawfik 2018). However, some methods are used frequently. For example, the production function approach is commonly used to assess the value mangroves provide to commercial fisheries (Barbier, 2000).

Valuation of ecosystem services

There are a handful of studies in Fiji on economic valuation of mangroves. Lal (1990) considers a few ecosystem services (water quality, agriculture, fisheries and forestry) using market and shadow prices and alternative costing. She finds that the economic value was US$5874 per ha/year in 1986 prices. Assuming a constant inflation effect of 3%, this would have doubled to just over $US113,000 per ha/year by 2020. Lal (2003) shows a table of diversity of mangrove based ecosystem valuation among Fiji, and some other Asian countries. For Fiji, she gets US$2706 per hac/year. More recently, along the lines of Lal, a study by SPREP (1998) also cited in the Fiji Biodiversity Strategy and Action Plan (2012) shows that the economic valuation of mangroves and estuaries in providing a few important ecosystem services (food production, nutrient cycling, habitat) amount to about US$1200 per hac/year and disturbance regulation to coastal areas amount to US$1500 per hac/year.

Gonzalez *et al.* (2015) show that total subsistence food provision from inshore fisheries and coastal resources was valued at about US$ 29.56 million per year. They find that small-scale inshore commercial fisheries produce a value of US$ 10.8-40.09 per hac/year. Commercial offshore fisheries (primarily tuna) produce US$ 0.08 per hac/year. They found tourism accounted for US$684 per hectare/year for coral reefs and lagoons; US$ 2,979.89/ha/yr) for mangroves. 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 US$ 6.36–10.61 million per year. They found 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 US$ 73.93 million and US$ 437.31 million, respectively.

The NOP also notes that in 2014, the estimated value of Fiji's marine ecosystem services was about US$ 1.2 billion annually. Fisheries was estimated to contribute about US$ 62 million annually mainly from subsistence farming. Small-scale inshore commercial fisheries produced a total national value of up to US$27 million, while the commercial offshore fisheries, primarily based on albacore tuna produced a total net value of US$10 million per year.

Note the figures above from different studies cannot be readily compared because of the difference in the number and types of ecosystem services included in the calculations. Nevertheless, these findings suggest that while mangroves are an important Ocean resource, supporting the national economy, fisheries exports, and livelihoods in the local economy. Given this backdrop, the following endeavors to re-assess and ascertain more recent economic value (in 2022 local currency) of Fiji's mangrove resources, through evaluating both the SNA impact and non-SNA benefits in Fiji.

3.2. Valuation of SNA benefits

The Approach

Analysing the SNA benefits of mangroves involved identifying and disaggregating economic activities that depend on mangroves and estimating their dollar values in current or constant prices. In this paper, we use the current price. Such an estimate would resemble measuring mangrove GDP (by activity), which is somewhat already recorded in Fiji's National Accounts, although not explicitly. Conceptually, the production boundary can be defined as activities that would (1) happen in mangrove sites [e.g., tourism], (2) activities that draw goods/services from the mangrove sites [e.g., mangrove timber, mangrove fisheries], and (3) those that provide goods and services to be used in the mangrove sites or the intermediate costs [e.g., equipment/structures/inputs] that may support the first two types of activities.

Ignoring minor details, such analysis takes a macroeconomy perspective on the SNA benefits consistent with the scope of the National Accounts. Useful indicators that can be extracted from this analysis could be (but not limited to) gross output, gross value added, employment creation and their indirect/induced economic impacts. Other social benefits can be estimated when data become more readily available.

The key analytical challenge in this exercise is to assign the "partials" or shares related to mangroves activities of the national accounts. These partials are defined and estimated below. Second, it could well be that there are some mangrove related SNA activities that exist in Fiji but haven't been captured in the National Accounts presently. The key ones likely are household own consumption and production. Because Fiji's statistical system is still developing, these can be accommodated once they are included in the official figures. Therefore, in order to estimate the SNA benefits we depend on the existing National Accounts data. This conservative approach allows clear rationalisation of the estimates to existing official release of GDP (and its components).

Methodology

In light of the data limitations, the strategy chosen was the development (or advance toward developing) mangrove satellite accounts. Since ocean economy satellite accounts are not defined in existing statistical standards, the Technical Guidance provides a typical structure as a guide (Table 13, pp 61, see Technical Guidance). We modify the same for our purposes for analyzing mangroves (Table 1). The rows are characteristic ocean economy sectors, and columns represent the measures employed to assess their performances. Performance can be measured in terms of Gross Value Added (GVA), Gross Output (GO) and employment. As the Guidance suggests, all these can be stated in terms of direct, indirect, and induced impacts.

a. Direct impacts are most directly associated with the activity, occurring in the ocean and are dependent on ocean products.
b. Indirect impacts refer to the inter-industry purchases (reflected in the measurement aggregates (GVA, GO and employment) triggered by direct demand for the Ocean activities in (a).

c. Induced impacts are generated by employees (in direct and indirect activities) spending their incomes.

For the purposes of this study, we will assess the direct benefits and make an attempt to study carbon content as a measure of indirect benefits. Needless to say, the latter is a very restricted measure of indirect benefits of mangrove ecosystems. This, together with the possible induced impacts can be analysed later (post-March 2022).

An important aspect of the current analysis is the establishment of the partials (share of activity of each industry that relate to mangroves). In the actual estimates to follow, this has been established using a variant of the Delphi Method which is well-established in the literature. In summary, the Delphi Method benefits from a consensus view on the pre-estimate of a parameter of interest. The consensus is established at a mid-point (mean or median) through stakeholder consultation.

In a similar exercise, although to estimate the benefits of a different environmental asset Rouleau et al. (2021) established economic valuation of USA's estuaries. This study builds on an earlier analysis done in 2009. This work and ours are similar in spirit along three main dimensions. They intend to present a clearer picture of the asset, quantify (although with difficulty) how these assets impact the real economy (and vice versa), and identify the inter-relationships between the assets and the economy; and how they have been changing overtime. In addition, Rouleau et al. (2021) extend their analysis to value two ecosystem services (coastal ecosystems infrastructure and blue carbon storage) for the USA, something that we also aspire to do for mangroves in Fiji beyond-March 2022. It is important to point out that the value of indirect benefits are expected to be higher and far-reaching to the society compared with those forthcoming from the direct impacts.

The specific ISIC codes for relevant sectors (following ISIC. Rev 4) are also provided in the Guidance, for reference. We shall maintain the presentation using the FSIC codes as applied in the National Accounts in Fiji for internal consistency and comparison. As the first step toward measuring direct SNA benefits, we present a theoretical summary of the methodology in Table 3.1 and position the relevant industries into the three dimensional analysis (In, From and Add to), see Table 3.2.

Results

For Table 3.1, Column 3 explains the relevant industries and the partials (minimum and maximum values) that reflect mangrove share in those industries are in Column 4. These partials have been estimated using rounds of discussion with the Fiji Bureau of Statistics (national accounts team), the core Fiji team and key industry players. Based on the partials alone, we are likely to see direct impacts in fishing, transport and construction related industries.

Using the three strands of assessment identified above (in, from and to mangrove sites) Table 3.2 presents how each identified activity fits these strands. We find (i) fishing, transport, scientific and recreational activities to be happening in the mangrove sites, (ii) logging, fishing, construction, transport, accomodation to be drawing resources from mangroves; and (iii) forestry (natural and intentional) and transport to add to the sites.

With Fiji's National Account (2018) data, the estimated SNA benefits of mangroves (using the above methodology) on relevant industries' outputs and employment are in Table 3.3 and 3.4. To gain a higher level of confidence in these estimates, we represent the SNA benefits using both upper and lower bound of the partials (Table 3.2), in exception to the employment data.

Table 3.1. Possible Mangrove based Activities in National Accounts.

Industry	FSIC	Description of Activity	Partial (Range)	Rationale
Forestry and logging	02101	Native forest (growing standing timber and operation of native forest tree nurseries).	0.05-0.10	Very limited use as timber (other than for construction) in maritime and village contexts. Small share of all native forestry. Consensus and industry confirmation.
Fishing & aquaculture [e]	N/A	Subsistence fishing (personal consumption).	0.50-0.60	Significant activity in Fiji (excludes deep sea fishing, which is mainly commercial). Consensus with local contexts and consistent with previous literature.
	N/A	Informal fishing (fishing and selling by unregistered and unlicensed fishermen).	0.20-0.30	Reasonable share (more significant would be deep sea fishing). Consensus with local contexts and consistent with previous literature.
	03121	Freshwater fishing on commercial basis	0.05-0.10	On a limited scale, mostly for consumption. Consistent with local contexts. Consensus.
	03122	Taking of freshwater crustaceans and molluscs (marine and freshwater crabs, prawns, kai etc in ocean, coastal waters and inland waters)	0.70-0.80	Highly significant share as most of these activities are freshwater based. Consensus and local fisherman/sellers' confirmation.
	03222	Freshwater aquaculture	0.05-0.10	On a limited scale, especially on a commercial basis. Consensus with local contexts.
Construction [b]	N/A	Informal construction (construction and repair of dwellings by oneself -unregistered and unlicensed)	0.10-0.20	Reasonable share especially in the smaller islands and maritime zones. Other materials (e.g processed wood and cement) are mostly used. Consensus and industry knowledge. Also notable in the Housing Census.

Transport and storage	N/A	Informal transport and storage (transport services provided by unlicensed & unregistered service providers. E.g. boat services in maritime areas)	0.50-0.60	Significant contribution in maritime zones and smaller islands. Consensus view.
	52221	Service activities incidental to water transport (transport of passengers, animals or freight; operation of terminal facilities such as harbors, piers and waterway locks etc.; and navigation, pilotage and berthing activities; and lighterage, salvage activities; and lighthouse activities e.g Fiji Ports)	0.02-0.05	Very limited contribution but prevalent in rural and maritime zones, consensus.
Accommodation and food service activities [c]	N/A	Informal accommodation and food service (provided by unlicensed and unregistered service providers).	0.03-0.05	Very limited share of the use of mangroves in supporting the informal accommodation component, especially prevalent in rural and maritime settings including in squatters. Does not include direct food service. Consensus and industry observation.
Professional, scientific and technical activities [d]	N/A	General government (research activities, meteorological services carried by government ministries and departments)	0.05-0.10	Very limited share in agriculture research and government. Consensus
	N/A	Total Formal Non-government Professional, scientific and technical activities (architectural and engineering activities; technical testing and analysis, scientific research and development).	0.05-0.10	Very limited share in other research institutions. Consensus.
Arts, entertainment and recreational activities	N/A	Informal Arts (sports activities and amusement and recreation activities, botanical and zoological gardens and	0.03-0.05	Very small share, includes recreational activities on shores and beaches. Consensus.

		nature reserves activities)		

Not coded (N/A) are informal activities consistent with the Fiji's National Accounts. **Source:** Fiji Bureau of Statistics, National Accounts and author's computations. Consensus with FBoS National Accounts team and key industry players.

Table 3.2 Fitting the Industries into Three Stands of Assessment

Industry	In mangrove site	From mangrove site	Add to mangrove site
Forestry and logging		√	√
Fishing and aquaculture	√	√	
Construction		√	
Transport and storage	√	√	√
Accomodation and food service activities		√	
Professional, scientific and technical activities	√		
Arts, entertainment and recreational activities	√		

Table 3.3. Estimated Value of Mangrove-based Industries in Fiji (2016-19) - Bound Estimates

Industries	**Contribution of mangrove to GVA ($Fm) (lower bound partial)**				**Contribution of mangrove to GVA ($Fm) (upper bound partial)**			
	2016	**2017**	**2018(r)**	**2019(p)**	**2016**	**2017**	**2018(r)**	**2019(p)**
Forestry and logging	0.86	0.67	0.82	0.77	1.72	1.34	1.65	1.54
Fishing and aquaculture [a]	16.77	17.18	16.56	15.32	21.64	22.13	21.99	20.25
Construction activities [b]	8.89	10.13	10.76	11.57	17.76	20.25	21.52	23.14
Transport and storage	4.56	4.56	4.30	4.24	6.27	6.42	6.06	5.91
Accommodation and food service activities [c]	0.38	0.38	0.39	0.39	0.64	0.64	0.65	0.65
Professional, scientific and technical activities [d]	9.25	9.64	9.85	10.20	18.49	19.28	19.71	20.41
Arts, entertainment and recreational activities	0.004	0.004	0.004	0.004	0.007	0.007	0.007	0.007
Total GVA	40.71	42.56	42.68	42.49	66.65	70.07	71.59	71.91
Standardized deviation from mean (z-score)	-1.73	0.55	0.70	0.47	-1.63	0.01	0.74	0.89
Outlier[e]	No	No	No	No	No	No	No	No

Not coded (N/A) reflects informal activity. [a] includes subsistence and informal fishing. [b] includes informal and formal in the private sector. [c] includes short-term and private sector activities in this industry. [d] includes government and formal private sector. The final grey column shows average of total employment (skilled and unskilled) in these industries. (e) Lower bound L1 = 40.21, L3=44.01. Upper bound L1=63.28, L3 = 73.84 (authors' computations). **Source:** Fiji Bureau of Statistics, National Accounts estimates and authors computations.

We find a minimum value of F$41m and a maximum of about F$43m using the lower bound of the partials. Using the upper bound, the minimum value is about $F67m and the maximum value points to about F$72m. Using partial averages, these figures represent a direct benefit in the range of about USD20m to about USD30m for Fiji annually between 2016-2019. Added with indirect benefits, the total economic benefit is expected to be significantly higher. Since the latter will be estimated in inflation-adjusted prices, we can adjust the above figures for inflation and compute total economic benefit when more details on indirect benefits becomes avaliable.

As a measure of robustness, we computed the standardized values of the direct benefits and confirm that none of them falls far away from zero. The test of outlier indicates that all the estimated values fall within the lower and upper limits in the two scenarios. These limits are in the notes of Table 3.3

Table 3.4 brings the data (estimated with average value of the partials) on activity and employment side by side and situates the direct benefits to the size of the economy and to that of each industry. The latter figures on employment are averaged over 2016-2019 period. We observe a few more insights in these results.

Using the average partials, we estimate close to FJD60m worth (or about USD28m) of direct benefits mainly through fishing and aqua-culture, construction and professional scientific activities. We can say that mangroves benefits are largely brought about by the fishing and aquaculture industry. Our initial estimates show that mangrove related industries contribute about 5.8% to total value added in these industries and about 0.78% Fiji’s GDP.

We also estimate average employment numbers on these industries (column 8) and find that about 170,000 jobs are created in these industries, of which direct employment is estimated at about 3500 paid jobs (on average) in between the 2016-2019 period. This is about 2% of all employment in these industries.

We provide further insights to Table 3.5 by adding details of the relative importance of mangroves to the industries GVA and economy at large over the period 2016-2019. The estimates are based on partial averages.Table 3.5 therefore provides a more holistic picture of activity, relative importance and employment generated in these industries. Total employment is total employment (formal and informal) estimated with paid employment data, with the assumption that in each sector, the share of formal employment is 60% of the total, consistent with Oum and Singh (2018). Table 3.5 show that the contributions grew by an average rate of about 1.1% per annum in the period 2016-2019. The data also show there were about 170,000 jobs in the broader connected industries in the period 2017-18.

As indicated by the Technical Guidance, with absence of detailed datasets, a satellite account is handy. At this initial stage, we are more confident on direct benefits on output and employment as reflected in Table 3.5. The direct benefits for 2018 and 2019 reference periods are shown, together with mangrove activity based generated activity. Since employment data available at the FBOS are not of very high quality, we had to estimate direct employment. Further refinements stretching to induced benefits and estimate of indirect employment could be pursued in the post-March period.

Table 3.4: Estimated Value of Mangrove based industries in Fiji (2016-19) - Average Estimates

Industries	**Contribution of mangrove to GVA ($Fm) (midpoint partial)**				**Avg. share of industry (%)**	**Avg. share of GDP (%)**	**Industry employment**
	2016	**2017**	**2018(r)**	**2019(p)**	**2016-19**	**2016-19**	**Avg. 2017-18**
Forestry and logging	1.29	1.01	1.24	1.16	4.20	0.000	283
Fishing and aquaculture [a]	19.21	19.65	19.28	17.79	22.76	0.170	1135
Construction activities [b]	13.32	15.19	16.14	17.35	5.14	0.138	2928
Transport and storage	5.57	5.67	5.35	5.24	0.79	0.051	33412
Accommodation and food service activities [c]	0.51	0.51	0.52	0.52	0.09	0.005	43465
Professional, scientific and technical activities [d]	13.87	14.46	14.78	15.31	7.46	0.137	14478
Arts, entertainment and recreational activities	0.005	0.006	0.006	0.006	0.175	0.000	1875
Total GVA	53.76	56.50	57.31	57.38	5.80	0.072	170,124

Not coded (N/A) to reflect informal activity. [a] includes subsistence and informal fishing. [b] includes informal and formal in the private sector. [c] includes short-term and private sector activities in this industry. [d] includes government and formal private sector. **Source:** Fiji Bureau of Statistics, National Accounts estimates and authors computations. The final (grey) column shows average of total employment (skilled and unskilled) in these industries.

Table 3.5. Mangrove Satellite Account (2018)

Industry	Impact on GVA $Fm, current (midpoint partial)				Impact on Mangrove Related Employment (000's)			
	2017		2018(r)		2017		2018(r)	
	Direct	Indirect	Direct	Indirect	Total Direct Employment	Indirect	Total Direct Employment	Indirect
Forestry and logging	1.01		1.24		—		—	
Fishing and aquaculture	19.65		19.28		276		239	
Construction activities	15.19		16.14		155		149	
Transport and storage	5.67		5.35		1770		1704	
Accommodation and food service activities	0.51		0.52		339		347	
Professional, scientific and technical activities	11.51		11.85		864		864	
Arts, entertainment and recreational activities	0.006		0.006		3		3	
Government [a]	2.95		2.93		216		216	
ENGOs	N/A		N/A		N/A		N/A	
Total	56.50		57.31		3623		3522	
Growth from previous year (%)	5.09		1.44		N/A		-1.78	
Whole economy (value in $Fm)	11,065		11,651		174,833		176,781	
Mangrove economy (% of whole economy)	0.51		0.49		–		1.13	

Notes: N/A = not available in existing national statistics. The grey columns indicate no data available at the moment, not necessarily nullified in the presentation format. Total direct employment includes skilled and unskilled. **Source:** Annual Paid Employment Statistics, and author's computations.

To allow complete measurement of both the economic activity (defined as directly related to mangroves) and the complete range of supporting (intermediate) inputs, normally an input-Output data (IO) structure is recommended. In the case of Fiji, the most updated IO is 2011 and a close kin to the required I-O table is the 2011 Supply-Use table. There has been no further updates of these by the FBoS. Literature informs the work of Oum and Singh (2018) who updated the 2011 Supply-Use table to estimate a revised I-O table. Due to the levels of aggregation in their work, it is hard to depend on the dataset produced in this paper. We shall attempt to develop the income and product account of mangroves when the baseline I-O is available/created and balanced, probably in the post-March 2020 period. This can shed more light on Table 3.4 and 3.5, as well as provide estimates of indirect benefits of both GVA and employment more robustly.

3.3. Valuation of non-SNA benefits

A Theoretical Discussion of the Approach

Although not estimated here, a summary of the approach and method will benefit researchers in the future. Analysing the non-SNA benefit of mangroves is data demanding and difficult because of pricing information. Establishing non-SNA benefits generally requires site surveys and/or mapping of the mangrove sites first. Important parameters such as estimates of the quantities of ecosystem services per unit of mangroves and the appropriate "prices" of those services are needed. Depending on the availability of data and research knowledge, one can estimate the total indirect benefit for the reference year. This together with the estimate of the direct and induced benefits will provide the total economic value of mangroves. To validate and replicate the results to other similar sites, accurate details of key parameters (carbon sequestration rate, mangrove extent, conditions, services derived, method being applied, and the conditions of the specified area) are needed.

A few approaches could be followed (1) one may select a strategic mangrove location and obtain the above estimates of relevant economic services derived using sample using surveys, or (2) select one ecosystem service of interest (to Fiji) and then apply the above approach to the entire country's sites, of course accounting for site variation characteristics, or (3) select one location and one ecosystem service's economic contribution and compute sample-based non-SNA benefit of that site. Although estimation of the non-SNA benefit is tedious and data demanding, many important parameters will be established and derived using this micro-level approach. This exercise will complement the above estimates improved with relevant I-O estimates.

There is extensive literature on ecosystem services valuation, however, many methods are not compatible with established national accounting and other statistical principles. The SEEA Ecosystem Accounting has suggested 3 levels of methods (undisputed/preferred, conditional, rejected) and 3 tiers of ecosystem services valuation methods depending on data availability and technical capacity, see pages 54-55 of the Technical Guidance. Based on these, we draw the following mangrove ecosystem valuation framework which would use tier 1 or 2 pricing methods depending on data availability.

Table 3.6. SEEA Approach to valuation of ecosystem services

Category	Ecosystem service	Is this applicable to Fiji	Physical quantity (to be estimated)	Pricing
Provisioning	Crops (plants for medicine)	√		Avoided costs
	Timber	√		Market price
	Fish (commercial and subsistence)	√		
	Water	Not seen as provisioning service		
Regulating	Carbon sequestration	√		Social cost
	Soil retention	√		Benefit transfer or avoided costs, whichever is available
	Air filtration	√		
	Water purification	√		
	River flood regulation	√		
	Coastal flood regulation	√		
	Water flow regulation	√		
Cultural	Tourism	√		Tourism revenue
	Nearby use (e.g recreation)	√		benefit transfer or opportunity cost
	Adjacent use (reflected in property values)	√		Expert estimation of premium

3.4. Mangrove Satellite Account Conclusions

These above estimates, although based on limited available information, show that in Fiji, industries spinning the most significant direct benefits of mangroves relate to fisheries and aquaculture, construction and professional scientific services.

We estimate a minimum value of F$41m and a maximum of about F$43m using the lower bound of the partials. Using the upper bound, the minimum value is about $F67m and the maximum value points to about F$72m. Using partial averages, mangrove direct benefit ranges about USD20m to USD30m for Fiji annually between 2016-2019. Added with indirect benefits, the total economic benefit is expected to be significantly higher.

Mangrove supported industries contribute just about 1.8% to total value added and GDP of Fiji. Data also shows that mangrove related activities support about 11,800 direct jobs which represent about 6.6% of all jobs created in these industries in Fiji.

A discussion of non-SNA benefits is below, and this section must be read in conjunction with selected estimates made in Section 2 (extent and condition). In this pilot, we only estimate carbon content (see Section 2) and detailed estimates of plausible ecosystem services are targeted for the post-March 2022.

4. Conclusion

This Fiji pilot is an initial attempt at developing Ocean accounts in Fiji focusing on mangroves (extent and conditions) and establishing the direct SNA benefits of mangroves. A component of the non-SNA benefits is selectively estimated in this paper. Our work is limited by the non-existent data on ecosystems assets, their use and valuations. With limited information and time at hand, we developed some reasonable initial estimates. The tentative findings (which can be greatly improved) can be improved by ground-truthing and development of I-O and Supply-Use tables, and site surveys to determine the indirect benefits.

Nevertheless, we present some indicative results in this pilot. First, mangrove mainly extends in the eastern, central and northern zones of the country, where both extent and cover are dense. The western region seems to have less vegetation of mangrove forests and has lost the cover relatively faster. We provide estimates for extent and cover for each of the 14 provinces of Fiji in this study. Satellite remote sensing was used to estimate mangrove canopy cover of50,800 ha in 2016, marking a decrease of 0.9% (562 ha) since 2008 . Depletion of mangroves is a concern for policy.

The provinces which have the highest mangrove forests are: Bua, Serua, Tailevu and Rewa; and they also sustain most above-ground biomass. Also note these are rural and relatively less human intruded mangrove forests of Fiji. Establishing more protected mangrove areas requires policy intervention. The mangrove ecosystems are worth conserving to enhance fisheries, blue carbon (carbon sequestration and capture) and shoreline protection. These benefits are crucial to Fiji's marine based industries and the livelihoods of people and communities in the maritime and coastal areas. These are also strategic for attracting international support/funding.

The initial findings point to about US$20-30m value of direct SNA benefits of mangrove forests annually in Fiji. The estimates show that this supports slightly about 0.5% of Fiji's GDP and GVA and about 1% to total employment in mangrove-related industries. These suggest that in order to enhance the economic contributions, the policy focus should be to protect mangroves on one hand and strategically innovate in the use of mangroves in industrial outputs. Fiji can implement more value-adding mangroves based activities such as mangrove tourism.

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