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SAMOA
MARINE ECOSYSTEM SERVICE VALUATION

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List of Acronyms

ADB	Asian Development Bank
CBA	Cost benefit analysis
CBD	Convention on Biological Diversity
CIM	Community Integrated Management Plan
CITES	Convention on International Trade in Endangered Species
CPI	Consumer Price Index
CPUE	Catch per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSM	Deep-sea mineral
DWFN	Distant water fishing nation
ECF	Ecosystem contribution factor
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organization
FFA	Pacific Islands Forum Fisheries Agency
FOB	Free-on-board
GDP	Gross Domestic Product
GEF	Global Environment Fund
GIS	Geographic Information Systems
GIZ	German Agency for International Cooperation
GNI	Gross National Income
HDI	Human Development Index
HIES	Household Income and Expenditure Survey
IMF	International Monetary Fund
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
MACBIO	Marine and Coastal Biodiversity Management in Pacific Island Countries
MNRE	Ministry of Natural Resources and Environment
MESCAL	Mangrove Ecosystems for Climate Change Adaptation and Livelihoods

MESP	Marine Ecosystem services Partnership
MEY	Maximum economic yield
MPA	Marine protected area
MSP	Marine Spatial Planning
MSY	Maximum Sustainable Yield
NBSAP	National Biodiversity Strategy and Action Plan
NESP	National Environment Strategy Plan
NGO	Non-government organization
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PICTs	Pacific Countries and Territories
PIFS	Pacific Islands Forum Secretariat
SCC	Social cost of carbon
SCS	Samoa Conservation Society
SDS	Strategy for Development of Samoa
SEEA	System of Environmental-Economic Accounting
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SUNGO	Samoa Umbrella for Non-Governmental Organizations
STA	Samoa Tourism Authority
TAC	Total allowable catch
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total economic value
TMDP	Tuna Fishery Management and Development Plan
UNDP	United Nations Development Program
USP	University of the South Pacific
VFR	Visiting friends and relatives
WCPFC	Western and Central Pacific Fisheries Commission
WTA	Willingness-to-accept
WTP	Willingness-to-pay

Executive summary

Samoa's EEZ covers 120,000 km^2 of ocean, which is 40 times larger than the country's land area. The economy is highly dependent on the stock of its natural ocean wealth which supports its fisheries, tourism, and coastal community livelihoods.

The benefits humans receive from ecosystems, called *ecosystem services**, are often hidden because markets do not directly reveal their *value* as nature provides these services for free. Failure to recognize the role that marine ecosystems play in supporting livelihoods, economic activity, and human wellbeing has, in many instances, led to inequitable and unsustainable marine resource management decisions. Economic *valuation* of *ecosystem services* provides information to decision makers on what could be lost or gained. Having access to information on the *value*s of *ecosystem services* facilitates more objective and informed decision-making.

This report describes, quantifies and, where possible, estimates the *economic value* of Samoa's marine and coastal resources. Seven key marine *ecosystem services* assessed in detail are: subsistence and commercial fishing; minerals, sand and aggregate mining; tourism; coastal protection; carbon sequestration; research, education and management. Other services explored include cultural and traditional values associated with the sea, potential future industries, and human benefits that have not yet been analyzed or exploited. As scarcity of data about many of these *ecosystem services* prevents the estimation of their *economic value*, the *value*s below should be regarded as minimum estimates. Data gaps are detailed in this report.

The subsistence coastal fishery for home consumption and the coastal (artisanal) commercial fishery which supply local markets, provide food and income security for many Samoan households. Both these fisheries are highly dependent on the health and protection of inshore habitats such as reefs, lagoons, and mangroves. The minimum estimate of the net annual *value* of Samoa's coastal fisheries is SAT$98.12 million (US$ 38.95 million) consisting of a subsistence fishery *value* of SAT$48.12 million ($US 19.85 million), and SAT$50 million (US$19.10 million) of coastal commercial harvest.

* Throughout the report, technical terms in italics are explained in the Glossary.

The relatively small sea cucumber fishery is currently harvested for the domestic market, with an estimated annual *net value* of SAT$139,165 (US$52,914). Given the importance of this fishery for local traditional food, implementing a sea cucumber management plan (Secretariat of the Pacific Community, 2015a) with an effective monitoring and enforcement mechanism to combat illegal trade will be necessary, as well as continuing experimental trials for re-stocking of degraded areas.

The deepwater bottom fishery is relatively small due to its variable nature. The estimated net value of this fishery in 2019 was SAT$207,928, while the average annual harvest is about 13.8 mt per year, with an annual *net value* of SAT$192,034 (US$79,060). The available biological data suggests a sustainable current rate of harvest. However, the deepwater bottom fishery has a boom-and-bust characteristic which requires careful management as the target species are generally slow growing and aggregate to spawn, resulting in susceptibility to overfishing.

Limited recent data and information is available on the operational aspects of multi-purpose Alia vessels that troll and longline for tuna. Catch from the smaller vessels is destined for local markets, with some catch sold to traders, while much of the catch from larger vessels is exported. The average annual catch from the troll fishery is about 249 mt, with a net annual *value* of about SAT$1,039,324 (US$581,749). The *value* of the troll fishery is likely to be about 20% higher than the *value* estimated by the Fisheries Division.

The longline albacore tuna fishery has an annual catch limit of 4,820 mt. Current harvest levels are around 80% of the total allowable catch (TAC) for albacore in Samoan waters. Tuna is a major fish export from Samoa, with most of the frozen albacore catch destined for canning in American Samoa. Government *revenue* of about US$1.3 million per year (SAT$3.42 million) is generated from access fees through licensing of foreign vessels. The net benefits to the industry (*gross revenue* minus costs) are about US$2.97 million to US$3.88 million (SAT$7.81million - SAT$10.20 million). The tuna industry provides some employment on locally based foreign vessels and at the landing sites and processing facilities for fresh and chilled tuna. These employment benefits have been estimated at about US$1.98 million (SAT$5.21 million), while the *value* of local purchases is estimated at about US$1.24 million (SAT$3.26 million).

Currently, Samoa does not have a commercial aquarium fishery. A thorough assessment of economic and environmental factors will be required before embarking on any future export of aquarium fish. Mariculture in Samoa is still at an early experimental stage but remains an option for supplementing local food supply and re-stocking degraded areas.

Regarding aggregate and sand mining, significant data gaps exist relating to the quantity and type of the sand resource, the location of activities, and the direct cost of collection and environmental impacts on local communities. The *revenue* from permits is the gross estimate of the benefit of sand and aggregate mining to the Ministry of Natural Resources and Environment (MNRE). Removal of sand and aggregate materials from beaches can increase the rate of coastal erosion as well as impacting coastal-based tourism activities that rely on Samoa's picturesque beaches.

Exploratory work during the 1970s to 1990s indicated moderate levels of Cobalt Rich Crusts (CRC) in Samoa's seamounts. Given subsequent improvements in knowledge and technology, further research of the deep sea areas is needed to better understand the ecological processes and functions of the seamounts and the deep sea area.

Tourism, as the main foreign exchange earner for Samoa, is highly dependent on healthy marine and coastal ecosystems. Benefits related to these ecosystems contribute SAT$109.48 million – SAT$348.87 million (US$41.64 million -US$132.65 million) in annual *economic activity* in Samoa; a minimum estimate of the *net value* of expenditure (44.5%) would be SAT$48.72 million (US$18.5 million) annually. Tourism benefits a variety of businesses and employees while also providing government tax *revenue*. The annual *value* of domestic tourism is estimated at about SAT$29.7 million (US$11.29 million). This is a conservative estimate as it only focuses on travel between Savai'i and Upolu.

The *value* of domestic and Samoan diaspora tourism could be further investigated through a more comprehensive assessment of social and cultural recreational *value*s associated with beach fale type accommodation, and coastal and marine-based activities for local and overseas Samoans. Marine related tourism activities can be a sustainable *ecosystem* benefit if managed and regulated. Fishing, particularly destructive types of coastal fishing, and beach mining, could negatively impact tourism benefits.

Samoa has been affected by devastating cyclones several times in the last few decades. A large majority of the Samoan population live in coastal areas, and many commercial activities and investments are located along the coast. Reef, mangroves, and seagrasses can provide continuing coastal protection from erosion and flooding in Samoa if they remain healthy and intact. The *value* of the *ecosystem service* is based on the savings from mitigating damage, or the cost of replacing natural ecosystems with man-made equivalents such as seawalls. The annual storm flooding damage cost to residential and tourist accommodation along the coastal areas mitigated by the presence of coral reefs, is estimated to be SAT$19.8 million (US$7.5 million). If reefs are damaged or absent, the estimated annual damages from storm flooding could be around SAT$29.9 million (US$11.4) or more.

Samoa's mangroves also provide carbon sequestration benefits to the world, which are valued at about SAT$146,084 per year (US$55,545). A high level of uncertainty exists about the current extent of mangroves and the risk of their destruction. As mangroves provide additional *ecosystem services* wherever they are present, the protection of these ecosystems is critical.

Marine and coastal areas attract foreign aid, and research and development grants for marine and ocean related activities supporting the Government of Samoa's conservation efforts. The broad estimation of projects linked to coastal, marine and climate change amounted to SAT$65.8 million (US$24.8 million) for the fiscal year 2019/20. Investment in marine and coastal biodiversity also includes many projects led by the MNRE and Fisheries Division, significantly contributing to overall aid and research. Funds used by individuals and institutions that research marine and coastal ecosystems, or advocate for their protection, mostly benefit the government, and have a trickle-down effect on the rest of the economy. Administration costs should be subtracted to determine the true net social benefit.

Other benefits derived from marine and coastal *ecosystem services* include bioremediation, aesthetic beauty and biodiversity, as well as cultural artifacts and handicrafts. Although this study has not quantified these benefits due to lack of data and logistical difficulties in conducting primary surveys during the COVID pandemic restrictions, they are to be recognised for positively impacting Samoans and the rest of the world. While the cultural *value* of marine areas to Samoans is difficult to quantify, an *opportunity cost* exists associated with individuals' investment of time and sacrifice of other activities to maintain their cultural practices and traditions. In doing so, they are demonstrating the *economic value* of culture.

Capturing these non-*market value*s through a more detailed assessment, such as using *contingent valuation* or *choice modelling*, would provide further information for programs designed to incentivize improved resource management and stewardship. Although the IUCN Marine Spatial Planning Programme is formally partnered with the Samoan MNRE, the project has recognised the importance of drawing on the talents and experience of the relevant government departments and associated agencies to optimise knowledge sharing about the *economic value* of marine ecosystems.

This study is a step towards a national process of recognizing the human benefits of natural ecosystems, which will hopefully lead to more equitable and sustainable management of Samoa's marine assets. It also serves as an inventory of cur*rent* information about the *economic value* of Samoa's marine and coastal assets, and as a starting point for more in-depth *valuation*s of each of the marine and coastal *ecosystem services*. More generally, Samoa should consider taking steps towards accounting for natural capital to ensure the long-term ocean health and improved *welfare* of its people.

Table 1: Summary table of the net economic value of marine and coastal ecosystem services in Samoa

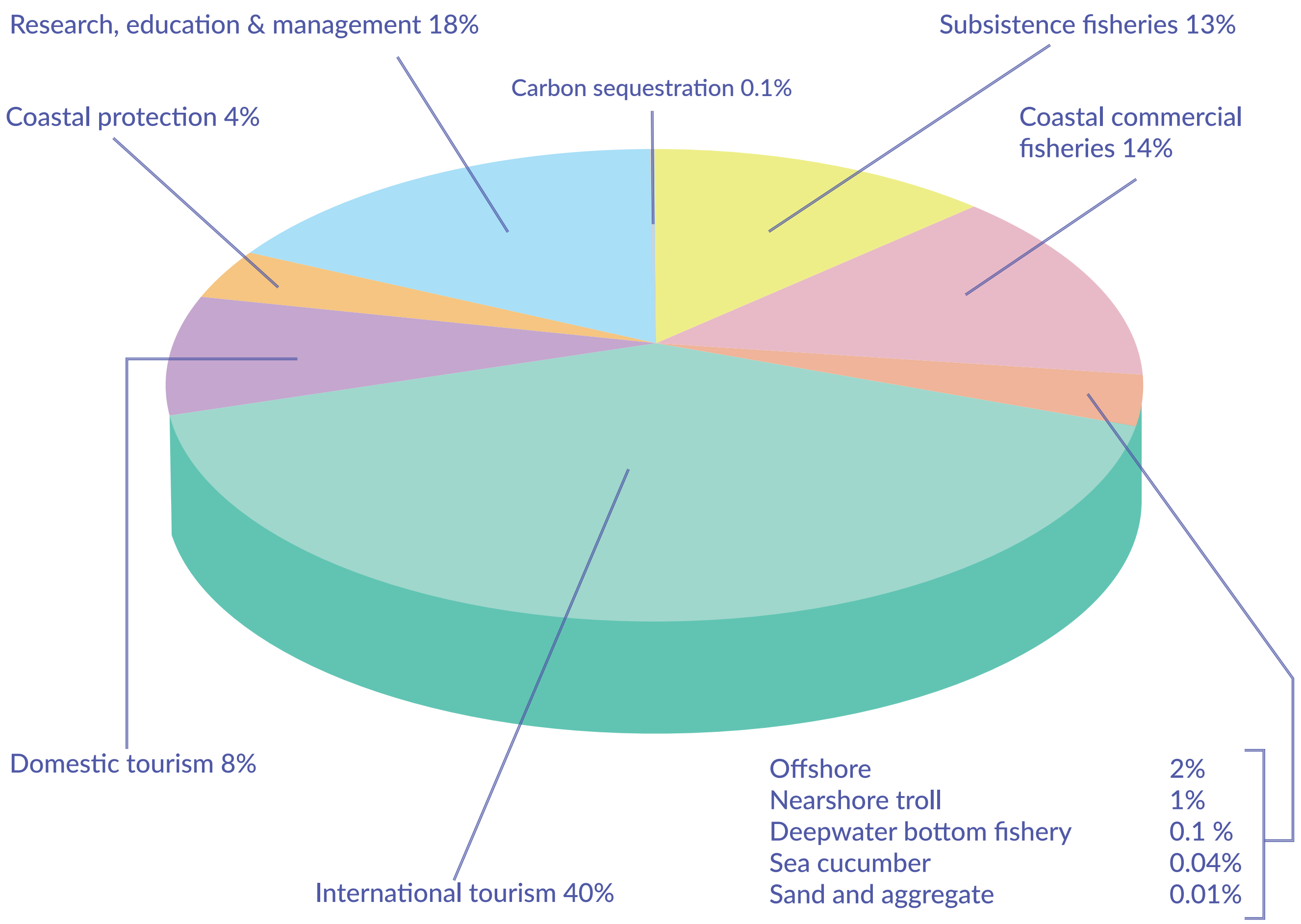
Ecosystem Service	Beneficiaries	Economic value (SAT$/year)**	Economic value (US$/year)**
Subsistence fisheries	Domestic households	50,240,000	19,100,000
Coastal commercial fisheries	Domestic households, Samoan fishers, some restaurants, and businesses	52,200,000	19,850,000
Sea cucumber	Domestic households, some fishers	139,165	52,914
Deepwater bottom fishery	Domestic households, some local fishers, some overseas relatives, and friends	207,928	79,060
Offshore tuna fisheries	Foreign and domestic operators, foreign consumers, government	9,000,000	3,425,000
Nearshore Troll	Domestic fishers and households, some restaurants	1,530,000	581,749
Sand and aggregate	Domestic business operators, some individuals and communities, government	26,430	10,049
International tourism	Foreign and domestic operators, foreign consumers, local communities, government	149,200,000	56,735,000
Domestic tourism	Domestic operators and households, government	29,700,000	11,290,000
Coastal protection	Domestic households and business owners who own properties, visitors	13,650,000	5,190,000
Carbon sequestration	Global and community	384,202	55,545
Research, education & management	Government and domestic households, consultants, businesses, researchers, students	65,776,000	25,000,000
Total		372,053,725	141,369,317

*Seabed minerals, mariculture, cultural & lifestyle, handicraft, bioprospecting, biodiversity existence, ocean-based energy (not assessed/not available)
**These figures represent the values estimated for 2019. (US$1 = SAT$ 2.63)

Table 1 shows the minimum estimated *value* of coastal and marine *ecosystem services* in Samoa to be around SAT$372 million in 2019, while Figure 1 illustrates the relative importance of the different *ecosystem services*. It must be noted that it includes aggregate value of research, education and management, and sand and aggregate mining, but does not cover many cultural values and other non-assessed resources. Figure 1 highlights an urgent need for policy makers and businesses to recognize the fundamental dependence of Samoa's economy on healthy ecosystems and associated *ecosystem services*. For example, the dependence of the tourism and fisheries sectors on coastal and marine based ecosystems.

The *direct use values* relate to provisioning services, *indirect use values* to regulating and maintenance services, and *non-use* (non-market) *values* to cultural services. While the latter was not *evaluated* in the current study due to data limitations, the *direct use values* are estimated as SAT$292.24 million (79.81%) of the estimated *total economic value* and the *indirect values* as SAT$79.81 million (21.5%). These *values* are crude estimates providing a comparison of the relative importance of the different types of *economic values* and the activities which contribute to them as shown in Figure 1.

Figure 1. The relative importance of coastal and marine ecosystem services in Samoa



The information in chapter 6 enables better understanding of the human benefits derived from Samoa's marine and coastal ecosystems. It allows comparison among the types and magnitude of benefits, as well as their distribution from different marine resources. Based on the findings in Chapter 6; Chapters 7 and 8 of the report suggest areas for attention and recommends specific actions that include the:

- Need to incorporate environmental values in Samoa's System of National Accounts through the development of environmental economic accounting framework;
- Need for an integrated management approach, including nature-based solutions that incorporate management and conservation strategies within the land and sea interface. For example, ecosystem-based management measures that consider land-based pollution and coastal development issues for managing coastal and marine ecosystems like coral reefs and mangroves areas;
- Need for research to determine consumer benefits from fisheries and tourism to assess the total net benefits derived from the coastal and marine ecosystems supporting tourism and fisheries activities;
- Need for a comprehensive socio-economic survey of coastal fisheries, including information on harvest details and cost of operations to assess the overall net benefits, the level of fishing pressure and the degree of commercialization of fishing operations, and level of subsistence to determine their appropriate management measures;
- Assessment of the negative impacts of dredging coastal sand and aggregate to determine appropriate management measures; and
- More in-depth research to identify cultural values of ecosystem services to identify the opportunity costs and willingness to pay for their continuation.

1. INTRODUCTION

1.1 Marine Spatial Planning

The International Union for Conservation of Nature's Oceania Regional Office (IUCN ORO), with funding from the European Union's Global Climate Change Alliance (GCCA+) Initiative, is working in partnership with the Government of Samoa (GoS) to develop a Marine Spatial Plan (MSP) for Samoa's Ocean.

Marine spatial planning is a practical way of managing marine areas to balance the demands of human activities with protecting the health of the ecosystems on which those activities depend. This is especially important in the Pacific islands, where livelihoods, food security, cultural wellbeing and economic dependencies are intertwined with the ocean and marine resources.

MSP involves establishing zones or boundaries according to certain activities. It requires informed and meaningful consultation using gender and rights-based approaches with traditional owners and users including: other coastal and marine users holding private and commercial interests, for example, government agencies; and civil society groups to minimise conflicts or inadvertently disadvantage certain groups.

Although the actual process may vary among countries, MSP involves specific steps necessary for effective outcomes. In Samoa, the Ministry of Natural Resources and Environment, through the Department of Environment Conservation (MNRE-DEC), is leading the MSP programme implementation with the support from key partners: SUNGO (Samoa Umbrella for NGOs); Conservation International (CI); the Waitt Foundation; and IUCN Oceania.

Under the MSP Programme, IUCN Oceania is primarily responsible for conducting national-scale economic assessment of marine and coastal ecosystem services in Samoa, including a data gap analysis. This national report serves as the quantitative measure of ecosystem benefits that can be used as a starting point to guide natural resource management decisions, inform policy, and champion the protection of ecosystems.

1.2 Problem statement

The ocean is centrally important to the people of the Pacific Islands, with a majority of the population living in its close proximity. Most island economies are heavily dependent on the resources of the ocean. However, increasing urbanisation and development are rapidly degrading ocean resources through unsustainable extraction, physical alteration and destruction of habitats, leading to loss of native flora and fauna and valuable ecosystems and their services. Coral reefs, already under stress from ocean warming and acidification, face further threats from pollution (Chin, *et al.*, 2012). Coastal ecosystems such as mangroves, are being lost to urban expansion. The degradation of coastal and marine ecosystems has economic and social impacts that threaten food security, fisheries, and tourism dependent on local biodiversity, while also increasing the vulnerability of coastal infrastructure to erosion, flooding, saltwater inundation and storm surges (Holland, *et al.*, 2019).

An urgent need prevails to address the impacts that threaten and undermine the health, integrity, and productive capability of the ocean. Given the multi-dimensional nature of this problem, an integrative approach is needed to comprehensively assess the *value* of the ocean's contribution to the well-being of the Pacific Island people, as well as the related costs and other risks. Such an approach will contribute to more informed policy decisions.

Problems arise firstly because the biodiversity of marine environment and its ecological processes and functions are not well understood, and secondly, because many of the *ecosystem* goods and services involved have characteristics of public goods that are not monetized or do not enter the market. These public goods nevertheless provide vital services for sustaining life support systems. The problems of management and governance of ecosystems stem from poor information and institutional failures.

Integrating marine resource management and biodiversity protection into mainstream national development planning, tourism sector planning, community livelihoods and food security, disaster mitigation and climate change adaptation is necessary to identify the interrelations and interdependence of the economy and the environment. This approach will identify the *economic benefits* and costs potentially overlooked by the sole and limited consideration of commercial *revenues* and costs (TEEB, 2014). Integrated management can also improve our understanding of the economic trade-offs among different kinds of *ecosystem services* and among those services and commercial economic activities that do not depend on the condition of marine ecosystems but may still impact them.

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

- Substantial resource-based economic activity exists outside of formal markets (e.g., subsistence based);
- Customary resource tenure arrangements poorly reflect individual economic decisions and pricing in markets;
- Government agencies in the region typically have relatively low capacity in environmental economics and green national accounting;
- Many countries of the region are relatively young and/or have lacked continuity in governance, which has contributed to a lack of long-term data collections, and analysis of ecosystem stocks and ecosystem service flows at the national level; and
- Many Pacific Island Countries and Territories (PICTs) have a history of a two-tiered economy, whereby one tier is export oriented, and the other traditional community-based and subsistence-oriented. However, both tiers are largely dependent on the same resource base. Planning and policy have generally struggled to address the needs of both tiers in developing a model of resource-based economic development at the national scale.

Identifying the *economic value* of marine and coastal ecosystems, and incorporating these findings into national planning, can facilitate more effective protection and sustainable use of marine species diversity. This in turn will help sustain the benefits communities derive from those marine and coastal ecosystems and associated *ecosystem services*. Therefore, this study is focused on addressing the above concerns in relation to Samoa.

1.3 Purpose and objectives

This national-level economic assessment of marine and coastal ecosystems has been undertaken using the *Guidance Manual – Economic Valuation of Marine Ecosystem services in the Pacific* (Salcone, *et al.*, 2016) and in a manner compatible with the global "The Economics of Ecosystems and Biodiversity" (TEEB) initiative. The work aims to contribute towards national development plans and marine resource management policies and decision-making.

The principal objective of the MESV is to identify, quantify and, as far as possible, *value* in monetary units the most relevant services received from marine and coastal ecosystems in Samoa. This provides a national assessment of the human benefits derived from marine and coastal ecosystems. A comprehensive survey of the current state of knowledge and priority knowledge gaps is the first step towards accounting for marine natural capital creating a *baseline* for more detailed *valuation* studies. The information provided within this report can be used to guide, design, and develop marine resources management plans, policies, assessments, legislation, and tools, such as Marine Protected Areas (MPAs) and Environmental Impact Assessments (EIAs).

This economic *valuation* aims to enhance ecosystem-based marine and coastal resource management leading to more resilient coastal and marine ecosystems, and improved effectiveness of conservation of marine biodiversity. It will also contribute to climate change adaptation and mitigation, and to securing and strengthening local livelihoods and food security.

1.4 Description of the scope and boundaries of analysis

Samoa is a Pacific Island country with an EEZ area of 120,000 km^2 of ocean, which is 40 times larger than the country's land area. Samoa's largest stock of natural wealth lies in the sea, providing numerous real and tangible benefits to Samoans and others.

The country belongs to a chain of 16 volcanic islands and numerous seamounts stretching west from Savai'i, to American Samoa's Rose Atoll in the southeast as shown in figure 3. The islands were formed by a series of volcanic eruptions with the oldest rocks being 2 to 3 million years old. The volcanic islands are clearly visible in the form of several dormant volcanoes and lava fields. The mountain ranges are intersected by valleys and rise steeply beyond the narrow coastal plains to a maximum of 1,859 m on Sava'ii and 1,100 m on Upolu. One study identified 30 distinct biogeographic regions in the Samoan Archipelago (including Samoa and American Samoa) containing 51 hotspots. (Kendall, *et al*., 2011).

Samoa's flora is one of the most diverse in Polynesia with about a quarter of the native plant species endemic to the country (Government of Samoa, nd) and 32% endemic to the Samoan archipelago. Samoa's limited number of fringing reefs at varying depths and locations around the archipelago possess rich fish fauna encompassing about 991 recorded species; 890 inhabiting shallow water or reefs, 56 found in deeper waters and 45 pelagic[1].

Non-fish marine fauna such as cetaceans, sharks and rays, marine turtles and seabirds are also important iconic species supporting the cultural heritage associated with the ocean. The marine environment has *ecosystem* diversity between the two main high islands with shallow and deep lagoons and fringing reefs, as well as seamount and open oceanic water columns. Some marine species are showing declining trends or threatened with extinction. About 65 marine species found in Samoa are listed as globally threatened on the IUCN's Red List of Threatened Species but the true number of threatened species is likely to be much higher[2].

This study provides a national-scale assessment of the *economic value* of *ecosystem services* of Samoa's marine environment. The geographic scope of analysis is national, thereby providing the broadest potential relevance to policy and decision-makers. For example, the subsistence coastal resource use and management, primarily takes place at the village or community level, but it does so within an economic and policy context at a national scale. Commercial fishing is often managed at the national scale (if not the regional or international scale). Infrastructure investment decisions to mitigate disaster risk in coastal zones are often best managed through national planning processes. Samoa has only one international airport, one main deepwater port and one primary commercial centre, thereby any economic development relying on these (e.g., relating to marine tourism) becomes an issue of national policy.

Samoa has committed to national-level planning and policy efforts under one or more UN Conventions. National capacity-building, data collection, storage and analysis helps reduce redundancy and potentially create synergies with other parallel efforts and country-scale commitments. Many of the compensatory and regulatory policy tools available and being used to promote behaviour in accordance with both natural wealth management and sustainable economic development objectives, are mostly national-level tools.

The assessment focuses on the *value* of *ecosystem services* in the year 2019 and provides information on trends over

1 Country Profile – Samoa. http://cbd.int/countries/profile/?country=ws (Accessed 24 July 2021).
2 Ibid.

time where possible. The global COVID pandemic starting in 2020 significantly impacted the use and *value* of some marine *ecosystem services* in Samoa. In particular, the number of tourists. Consequently the *value* of the coastal environment to tourism has dropped dramatically in the past year. The *value* of fisheries has also been affected by the decrease in demand by tourists combined with transportation constraints. On the assumption that the use of marine *ecosystem services* is likely to rebound to pre-COVID levels when the pandemic is brought under control, this study does not provide *values* for 2020 and considers 2019 *values* a better representation of the *ecosystem* service *value* for the purpose of long-term decision making.

1.5 Report outline

The report provides details of the country-specific context in which the economic *evaluation* was conducted and explains the methodological framework for the analysis. The specific methods applied in the report are discussed briefly (see Salcone, *et al*. 2016 for detailed methods). Information is synthesized primarily from existing data and reports and conclusions drawn where possible. Important knowledge gaps are identified and recommendations made for future research.

The report describes and quantifies Samoa's marine and coastal resources and where possible, calculates their *economic value*. Seven key marine *ecosystem services* are *evaluated* in detail: subsistence fishery; commercial fishing; minerals and aggregate mining; tourism; coastal protection; carbon sequestration; and research, management, and education. Additional services explored include cultural and traditional *values* associated with the sea, non-market *existence values*, potential *values* and other human benefits yet unexplored.

Samoa's institutional and policy context are described in Chapter 2. This includes a brief analysis of national policies, objectives, and initiatives that could use information about the human benefits of marine ecosystems provided by this report. The TEEB initiative and global framework for *ecosystem service valuation* are presented in Chapter 3. Chapter 4 provides an overview of economic *valuation* literature relevant to Samoa and the Pacific Island States and Territories and the technical *valuation* methods are explained in Chapter 5.

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

Samoa experiences annual variability in the magnitude of benefits from marine and coastal ecosystems, particularly with regards to commercial fisheries. In some instances, due to variations in harvests and changes to the health of the ecosystem, an annual *value* of the *ecosystem* service is hardly relevant. These and other methodological and data issues are discussed in the **Uncertainty** section. In the **Sustainability** section, the report indicates whether current resource uses are sustainable, that is whether the natural benefits can be expected to continue, to increase, or to decrease with current practices.

The benefits of different *ecosystem functions* may accrue to few or many, nationals or foreigners, businesses, or consumers. In order to understand the incentives that motivate different resource use patterns, it is important to consider who receives the benefits from the various marine and coastal ecosystems in Samoa. The **Distribution** section for each *ecosystem* service describes the distribution and considers equity of existing *ecosystem* benefits.

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

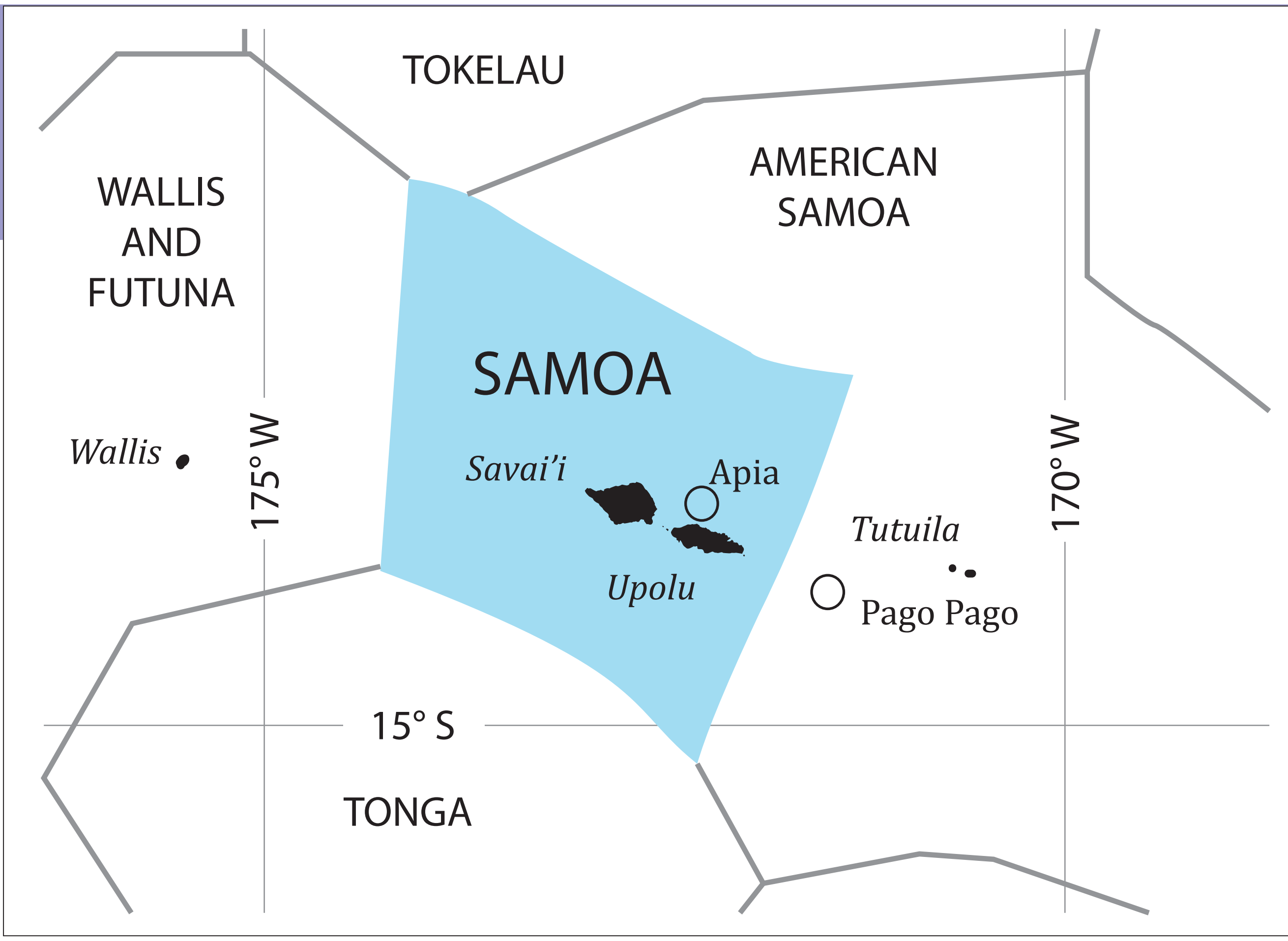


Figure 2: Geographic location of Samoa

Source, Gillett 2018.

2. Context

2.1 Geographic context

Samoa is made up of nine islands with four main inhabited islands (Savai'i, Upolu, Manono and Apolima), situated between 13°S and 15°S latitude and 168°W and 173°W longitude (Fig. 1). Samoa's total land area is 2,830 km², and its reef area is about 490 km². Samoa has the smallest exclusive economic zone in the Pacific of about 120,000 km² (Tiitii, Sharp, & Ah-Leong, 2014), and is bordered to the north by Tokelau, to the south by Tonga, to the east by Cook Islands and American Samoa, and to the west by Wallis and Futuna. Savai'i is the largest island with a land area of about 1,700 km² and Upolu is the second largest at 1,100 km² in land area. Figure 2 and Figure 3 show the geographic location of Samoa.

2.2 Demographic and economic country profile

In 2019, Samoa's population was estimated to be around 200,000, with an annual growth rate of 0.4% (World Bank, 2020). Samoa's capital, Apia, is located on the north coast of Upolu and had a population of 37,391 in 2016 (Samoa Bureau of Statistics, 2016). The country consists of about 340 villages for administrative purposes, and is divided into 43 districts. These districts are further grouped into four census regions, namely Apia Urban Area (AUA), North-West Upolu (NWU), Rest of Upolu (ROU) and Savai'i (SAV) (Samoa Bureau of Statistics, 2018). About 70% of the villages are on the coast, which puts pressure on the coastal resources and their habitats.

Figure 3: Islands of Samoa

Source: Ministry of Finance, 2016.

The annual GDP was SAT$2,064.2 million in constant 2013 prices at the end of September 2019 (Samoa Bureau of Statistics, 2019), giving an estimated per capita GDP of SAT$10,321. The official currency used in Samoa is the Samoan Tala (SAT) dollar and all monetary *values* are provided in Samoan dollars and where possible converted to equivalent US dollars.

The economy of Samoa has been dependent on development aid, family remittances from overseas, tourism, agriculture, and fishing. The service sector accounts for nearly two-thirds of GDP, and employs approximately 50% of the labor force (CIA, 2019). Commerce and Public Administration were the biggest industries in the services sector, contributing to 32% and 8% of total GDP. Agriculture and Fishing contributed around 10% of total GDP in 2017 (Samoa Bureau of Statistics, 2018).Tourism is an expanding sector, accounting for 25% of GDP; with 74% of total arrivals as visitors to the islands in 2017 (Samoa Bureau of Statistics, 2018). The principal markets for tourism are Australia and New Zealand and the main attractions are diving, beaches, rainforest trekking and swimming (Commonwealth Network, 2020).

According to the Household Income and Expenditure Survey data, of the total of 27,865 households recorded in 2017 in Samoa, 0.2% of households accounted for fishing and gathering sea products as their main source of income, while 54.5% of households depended on self-reliant strategies (i.e the *value* of their own produced goods) and 4.6% on remittances (Samoa Bureau of Statistics, 2018).

Samoa is vulnerable to the impacts of extreme weather events including devastating storms and natural disasters. For example, in September 2009 an earthquake and the resulting tsunami severely damaged Samoa and nearby American Samoa, disrupting transportation and power generation, and resulting in about 200 deaths. In December 2012, extensive flooding and wind damage from Tropical Cyclone Evan killed four people, displaced over 6,000, and damaged or destroyed an estimated 1,500 homes on Samoa's Upolu Island (Samoa Bureau of Statistics, 2018).

2.3 Institutional context

In 1900, Samoa became an American Protectorate along with Tutuila and the Manu'a Group, whereas Upolu and Savai'i were combined to form German Samoa. New Zealand took over the administration of German Samoa in 1914 at the onset of World War I. Samoa was the first Pacific Island country to gain independence in 1962. The constitution was established in 1960 and blends traditional and democratic institutions and processes. (Samoa Bureau of Statistics, 2018).

Samoa has a hierarchical society where chiefs (*matai*) govern village affairs. The social unit of Samoan life is the '*aiga*' or extended family. Each '*aiga*' elects a *matai* through consensus, who holds the family title. The *matai* assumes responsibility for directing the use of family land and other assets belonging to the *aiga*. He must honour the title he bears and the people he represents through his behaviour. In return for his leadership, the *matai* is rendered services by the *'tautua'* (untitled) village members (Samoa Bureau of Statistics, 2018).

The 1990 Village Fono Act and 2017 Village Fono Amendment gives village councils authority over village law and order, health, and social issues. The *matai* constitutes the council or *'fono'* of the village. Presiding over the *fono* is the '*Sui o le Malo*' (village mayor) who is appointed by the government on recommendation from the village council.

Rooted in this social organisation is the Samoan Way or '*fa'a-Samoa*', which places great importance on the dignity and achievement of the group rather than its individual members. Religion plays an important role in Samoan life where most of the people strongly adhere to the Christian faith.

At the national level, the Division of Fisheries in the Ministry of Agriculture and Fisheries is the main institution involved in decision-making affecting marine and coastal resources in Samoa. The Division of Fisheries is primarily responsible for the formulation and implementation of policies in the fisheries sector. The involvement of communities through the *matai* system has been an effective way to develop and monitor village fisheries (Government of Samoa, 2020). The Coastal Fisheries section focuses on inshore fisheries through collecting data on landings and conducting market surveys, as well as monitoring fish reserves to maintain their ecological processes. The Oceanic Section oversees the management and development of the offshore marine resources, while the aquaculture section undertakes experimental work in mariculture and tilapia production.

Other government departments are also involved in the management and implementation of coastal and marine related projects, such as the Ministry of Natural Resources and Environment (MNRE), the Samoa Tourism Authority, and the Maritime Authority. The Ministry of Natural Resources and Environment has a wide variety of portfolios that work either independently or in coordination with each other to support marine and coastal conservation and management activities. These are: environment conservation, land management, renewable energy, climate change adaptation, forestry, water resources and sanitation.

The Division of Environment and Conservation focuses on issues that threaten Samoa's biodiversity from land and sea. The Division is also leading the implementation of Samoa's National Biodiversity Strategy and Action Plan (NBSAP), Integrated Coastal Management and Protected Area Committees and the Samoa Ocean Strategy 2020-2030. The Ministry is responsible for implementing environmental safeguards through its development consent review process to ensure developments do not adversely impact the environment and managing and minimising identified risks and hazards. Climate Change and Disaster Risk Management are addressed as cross-cutting issues with the Ministry.

The National Environment Sector Plan (2017-2021) identifies the implementation arrangements for the sector, which include clarification of institutional roles and responsibilities, coordination mechanisms to facilitate sector-wide planning, implementation, monitoring and reviews, and evaluation and reporting under the guidance and leadership of the National Environment Sector Steering Committee (Ministry of Natural Resources and Environment, 2017).

A wide mix of public and private sector organisations are involved in the management and development of the tourism sector. The Tourism Sector Committee is a high-level body comprising various ministerial CEOs and private sector representatives who keep an oversight on the sector policy. The Samoan Tourism Authority is the lead agency for policy, planning, marketing, visitor information, market research and sector coordination, and reports to an independent board and to the Minister of Tourism. The Samoan Tourism Authority's functions also includes overseeing issues relating to tourism and climate change and tourism cyclone recovery programs.

Mining in Samoa consists of coastal sand mining and aggregate quarrying for building roads and other infrastructure. The principal overarching Lands, Surveys and Environment Act (1989) governs the mining of minerals in Samoa. The land management section of MNRE is responsible for overseeing sand mining activities, as well as monitoring illegal sand mining, and processing license applications through a permit system that requires an environmental/resource assessment. The enforcement of permit conditions by the Ministry is hampered by limited capacity and resources, as well as by the customary ownership nature of the land, which in the view of communities, extend to beaches even if they are below the high-water mark (SPC Geoscience Division, 2011).

Besides governmental organisations: NGOs and civil society groups are also active in Samoa at the community level to facilitate the implementation of resource management and conservation programmes. The goal of the Samoa Umbrella for Non-Governmental Organisations (SUNGO) is to co-ordinate all national and civil-based NGOs by providing close networking and easy accessibility to information, thus strengthening the respective NGOs in achieving their goals. Samoan civil society is particularly active in health matters, gender and human rights and environmental conservation and disaster relief. For example, the National Environment Society (*O Le Siosiomanga Society Inc*) and the Samoa Conservation Society are local NGOs promoting conservation of Samoa's biodiversity and natural heritage.

Samoa also has several international and regional organisations whose work programmes are aligned with Samoan government national development priorities and strategies, thus either directly or indirectly affecting the management and development of coastal and marine resources. These include the UNDP, FAO, SPREP and Japan International Cooperation Agency (JICA).

A key institution for resource management in Samoa is the local level village management systems that have evolved under the guidance of village chiefs, such as the Community Based Fisheries Management (CBFM) and the Community Integrated Management Systems (CIMS). The emphasis of the latter is on integrated ecosystem-based adaptation and applying the ridge to reef concept that also serves to address climate change interventions.

2.4 Policy context

The management of Samoa's marine and coastal resources is guided by multiple sectoral strategies and policies that are implemented by different ministries and departments. Consequently, a number of legal frameworks exist which either directly or indirectly influence the use and management of coastal and marine resources. These include the following: the Land Surveys and Environment Act (1989), the Marine Pollution Prevention Act (2008), the Disaster Management Act (2007), the Maritime

Zones Act (1999), the National Parks and Reserves Act (1974), the Planning and Urban Management Act (1974), the Water Resources Management Act (2008), the Waste Management Act (2010), the Fisheries Act (1988), and Fisheries Regulations (1995), the Village *Fono* Act (1990) and village by-laws, and the Fisheries Management Act (2016), while the Constitution of Samoa (1960) among other things, governs land ownership and use, including areas below the high water mark. The finalization of the Environment Management and Conservation Bill and the CITES Bill will further strengthen the regulatory framework for the management of marine resources.

In terms of policy guidelines, the Strategy for the Development of Samoa (SDS) 2016 - 2020 provides the overarching framework for Samoa's sustainable and resilient development (Ministry of Natural Resources and Environment, 2017). The National Environment Sector Plan (NESP) 2017 - 2021 articulates the roadmap for the Environment Sector for the period 2017 - 2021. It is based on the State of the Environment (2013) report and lessons learned from previous NESP (2013-2016), as well as from the outcomes of the Sector SWOT Analysis conducted as part of the NESP review and update process.

The NESP outlines the sector's vision, goal, and a framework for action, in line with the Strategy for the Development of Samoa (SDS) 2016-2020, the sector policy and legislative framework, and regional and international obligations under various multilateral environmental agreements that Samoa has ratified. The NESP forms a consolidated Oceans Management and Development Framework that includes coastal management, marine conservation, fisheries, and ocean health monitoring (Ministry of Natural Resources and Environment, 2017, p. 18).

Samoa's current National Biodiversity Strategy and Action Plan (2015-2020) (NBSAP) sets out the country's priorities for biodiversity protection, conservation, and sustainable management of its biological resources. It builds on the original NBSAP (2001) and is developed through a consultative process with stakeholders. The Plan adopts the Global Strategic Plan for Biodiversity 2011 – 2020 and the Aichi Biodiversity Targets (ABT) as a framework so that it can also facilitate global biodiversity monitoring and assessment based on the three main objectives of the Biodiversity Convention – *conservation of biodiversity, sustainable use and equitable sharing of its benefits* and has clear linkages to the National Environment Sector Plan and Strategy for the Development of Samoa (SDS) (Ministry of Natural Resources and Environment, 2015).

The NBSAP aims to mainstream environmental issues into local budget allocation and accounting (Ministry of Natural Resources and Environment, 2015, p. 7) and identifies 20 targets which need to be achieved to realise the plan's strategic goals. These targets either directly or indirectly rely on maintaining the integrity of Samoa's ecosystems. For example, Target 2 states that "*By 2020, at the latest, biodiversity values [would] have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.*" (Ministry of Natural Resources and Environment, 2015, p. 7).

The NBSAP also encourages the exploration of *payments for ecosystem services* (PES), including those on land under customary control, as incentives to reinforce community participation and commitment to conservation objectives. PES can also be used to demonstrate the links between conservation, sustainable use, and the livelihoods of local resource owners (Ministry of Natural Resources and Environment, 2015, p. 10). These intentions clearly highlight the importance of *valuation* of natural resources such as marine and coastal ecosystems.

The Samoan Tourism Sector Plan establishes the framework for the development of tourism in Samoa for the 5-year period (2014-2019). Sustainable tourism development guidelines and management practices are an integral part of Samoa's tourism sector plan (Samoa Tourism Authority, 2014) . Balancing environmental, economic, and socio-cultural aspects of tourism development is essential for its long-term sustainability. The Plan recognises the fragile environment and unique culture which needs to be preserved to market Samoa as a tourist destination.

The Fisheries Act (1988) and the Fisheries Management Act (2016) provide the legal framework for management and development of fisheries resources. Other regional policies and strategic guidelines for the fisheries sector include: The Future of Fisheries (2015), a Regional Roadmap for Sustainable Pacific Fisheries which supports policies and legislation for involving coastal communities in the management of fisheries, and the Noumea Strategy: a New Song for Coastal Fisheries (2015) which emphasises community-based approaches to provide food security and long term economic, social and ecological benefits to coastal communities.

The Samoa Coastal Fisheries Management and Development Plan (2013- 2016) and the Samoa Tuna Management and Development Plan (2017-2021) provide strategies and plans of action to address fisheries resource management issues. The Tuna Management Plan proposes a harvest strategy as a management tool to meet the regional obligations to control tuna catch. In light of the above initiatives, the Fisheries Policy for Samoa is currently under review.

The Sea Cucumber Fisheries Management and Development Plan (2013-2018) aims to ensure resources are managed sustainably by protecting sufficient spawning biomasses to ensure continuous recruitment and controlling aquaculture and ranching operations to ensure wild stocks are managed (Secretariat of the Pacific Community, 2015a).

Samoa has many important policies, plans and legislative instruments in place to manage ocean and marine resources. The Samoa Ocean Strategy (2020-2030) outlines a pathway towards sustainable use and integrated management of Samoa's ocean and marine resources (Government of Samoa and Conservation International, 2019). The strategy encompasses the many uses, and *value*s derived from Samoa's waters, including subsistence and commercial fishing, marine transport, recreation, eco-tourism, as well as addressing the many threats that may prevent such *value*s from being realised.

In addition to being a signatory to the CBD, Samoa is a party to the following international conventions that have formed part of the legal and policy framework for biodiversity conservation in Samoa: the Ramsar Convention for Wetland Conservation (1971) which Samoa signed in 2004; the World Heritage Convention of 1972; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 2005; the 1982 UN Convention on the Law of the Sea which established the broad legal framework for protection and governance of the oceans; Agenda 21 (which resulted from The UN Conference on Environment and Development, Rio Declaration of 1992 and includes the requirement for protection of living marine resources and use limitations by designing protected areas and by other means); the 1994 Barbados Declaration and Programme of Action, the 2005 Mauritius Strategy and the 2014 SAMOA Pathway (focusing on sustainable development of small island countries); the 2002 World Summit on Sustainable Development (which sought to establish networks of MPAs by 2012), and the 2030 Agenda and the SDGs which included a stand-alone goal on the conservation and sustainable use of the ocean and its resources.

Regional and national policy attention to ocean governance in the Pacific has brought an international response to increasing anthropogenic threats mostly from increased resource use and climate change. Political leaders are putting oceans on national and international agendas to maximise *revenue*s, sustain livelihoods and minimize coastal vulnerability and ecological degradation (Keen, Schwarz, & Wini-Simeon, 2018). Under the Framework for Pacific Regionalism, held in 2017 in Samoa, the Pacific Islands Forum Leaders endorsed '*The Blue Pacific*' as a new narrative for collective political action in the Pacific that calls for working together as one 'Blue Continent'. *The Blue Pacific* aims to harness the region's shared ocean identity, geography, and resources to focus on policy development that will drive positive change in the Pacific's socio-cultural, political and economic development (The Pacific Islands Forum Secretariat, 2020). This framework provides further impetus for Samoa to take stock of the status and potential of its marine resources.

2.5 Stakeholders' input

As part of IUCN's MSP Programme, a workshop on "Identifying Special, Unique Marine Areas of Samoa" (SUMA) under the umbrella of **Implementing Samoa's Ocean Strategy** was held in Apia on the 4th of March 2020.[3] This project on MESV was presented at this SUMA workshop (**See the list of participants in the appendix**). The aim of the presentation was to outline the study objectives, raise awareness and solicit interest and suggestions on the design and implementation of the project in Samoa.

Following the workshop, a series of focus group consultations were held with government departments, workshop participants and other agencies from the 5th to the 13th of March 2020 (**see list of attendees and institutions in the Appendix)**. The aim of these consultations was to collaboratively identify what work has already been done on natural *ecosystem services* and environmental *valuation*, what information and data already existed in the respective departments and institutions that could be utilised, and to establish a focal point of contact for the project. This enabled input from various government departments and institutions and established an interactive platform (coordinated by the IUCN/MSP Project Manager) for work on the project to prepare a draft study. This served as an

3 The first part of the implementation of this project commenced amidst the government restrictions on health and quarantine due to measles outbreak in Samoa from December 2019 to January 2020, and the Covid-19 Pandemic restrictions and closure of international borders. In such circumstances, the focussed group consultations were found to be effective as it was not possible to mobilise resources to conduct primary surveys to ascertain the communities social and cultural values of biodiversity protection or recreational opportunities.

informative guide for greater awareness and motivation for continued cooperation and capacity building.

The draft report was independently reviewed by Nicholas Conner, a conservation economist from Australia and preliminary findings were presented to the second meeting of the Support Working Group for the National Marine Spatial Planning Project (MSP-SWG) on the 14th of July 2021. Comments and suggestions on the draft report from the stakeholders were further integrated into the final report.

2.6 Related projects and initiatives

There are several international and regional commitments and initiatives that are relevant to this study. Given the multi-sectoral and cross-cutting nature of ocean uses and impacts, the Government of Samoa has developed the Samoa Ocean Strategy (2020-2030) [SOS] to provide the integrative foundation for sustainable use and management of marine and coastal resources. This report is directly relevant to addressing the strategies outlined in the SOS report.

The Ocean Strategy supports commitments towards the UN Sustainable Development Goals, in particular, SDG 14: Life Below Water, as agreed at the UN Oceans Conference in New York in 2017. The Strategy is aligned with Samoa's global commitments, including the Convention on Biodiversity, the UN Framework for Climate Change, the UN Convention on the Law of the Sea and the SAMOA Pathway (Government of Samoa & Conservation International, 2019). The Ocean Strategy also supports Samoa's efforts to implement the UN Fish Stocks Agreement, the Western and Central Pacific Fisheries Convention, the Ramsar Convention, and the International Coral Reefs Initiatives. Furthermore, the implementation of the Ocean Strategy will also reinforce Samoa's fulfillment of the Aichi Targets under the Convention of Biodiversity as outlined in the NBSAP (2015-2020).

There is also leverage through other parallel regional commitments such as the Pacific Island Regional Ocean Policy and Framework (2009), and those supported under the Framework for Pacific Regionalism (2014) which calls for a regional approach, given their unique circumstances as small island economies with vulnerable environments. In 2010, the Pacific Island Forum Leaders agreed to a forward-looking strategy for the Pacific Islands which identified seven goals for oceanic and coastal fisheries in the next ten years, together with indicators to measure progress.

While the strategies outlined are facilitated by regional agencies, the policy direction and implementation are at the national level requiring countries to annually report back to the regional agencies using a report card on their progress (Forum Fisheries Agency & Secretariat of the Pacific Community, 2011). Another important driver is the 'Blue Pacific' endorsement by the Forum Island Leaders in 2017. Through this narrative, the Pacific Island Leaders reaffirm the connections of Pacific people with their natural resources, environment, culture and livelihoods (Forum Secretariat, 2020).

As discussed under section 2.4, the National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 outlines Samoa's priorities for biodiversity protection, conservation, and sustainable management of its biological resources by adopting guidelines from the Global Strategic Plan for Biodiversity (2011-2020). In addition to the above, Samoa has other commitments, interests, and projects that this report can contribute to, including:

- Pacific Regional Environment Programme Strategic Plan (2017 – 2026);
- Pacific Oceanscape Framework;
- Framework for Resilient Development in the Pacific (FRDP);
- System of Environmental Economic Accounts (SEEA) and in particular the Experimental Ecosystem Accounts developed by the UN Statistics Division and national ocean accounts;
- Framework for Nature Conservation and Protected Areas in the Pacific Islands Region 2014- 2020; and
- Restoration of Ecosystem services against Climate Change Unfavourable Effects (RESCCUE).

3. Conceptual framework

The principal objective of the MESV is to identify, quantify and, as far as possible, *value* in monetary units the most relevant services received from marine and coastal ecosystems in Samoa. This was done to provide decision-makers and policymakers at all levels with information about the *economic value* people derive from marine and coastal ecosystems. For this reason, significant effort was made to conduct the work collaboratively, and with close interaction with key government and non-government stakeholders, as well as technical staff in Samoa and IUCN Oceania Office. The following section describes the terms and definitions used and the context of *ecosystem services*.

3.1 Definitions

Ecosystems

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

Ecosystem services

Ecosystem services are the benefits humans receive from the natural attributes and functions of ecosystems (some examples are provided in Table 2). These benefits include material goods, such as sand and aggregates or fish, or biological services, such as the treatment of human waste and carbon sequestration.

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

Table 2: Marine Ecosystem services

Provisioning	Regulation & Maintenance	Cultural
• Seafoods • Building materials • Minerals • Pharmaceutical products	• Coastal protection • Carbon sequestration • Bioremediation • Filtration • Habitat • Nursery grounds	• Existence • Aesthetics experiences • Cultural identity • Traditional ecological knowledge • Education and training
Provisioning includes: material goods; energy, and outputs of ecosystems tangible things that can be exchanged or traded; used directly or as raw materials; and consumed.	Regulating and maintenance include ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people. These ecosystem outputs are not consumed but affect the performance of people and their activities.	Cultural and social services include all non-material ecosystem outputs that have symbolic or intellectual significance.

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

Economic value

Economic value refers to the quantified net benefit that humans derive from a good or service, regardless of a market and monetary transaction. *Economic value* needs to be distinguished from *economic activity* (also known as financial or exchange *value*), which is a measure of cash flows and is observed in markets[4]. While *economic activity* from market transactions is often used to calculate the *economic value*, *economic activity* is not in itself a measure of human benefit.

Economic activity, however, is an interesting measure[5]. The number of formal sector jobs and the level of capital investment are closely related to *economic activity*, which is relevant to the public, civil servants and policymakers. This report focuses on measuring *economic value*.

Consideration must be given to avoid comparisons between *economic activity* and *economic value* as although both can be represented in dollars per year, they are different measurements of benefits. It is worth noting that Government Revenue from taxation on specific economic sectors or activities is not regarded as part of *economic value*. In national assessments, however, it is relevant to record public *revenue* from taxation of non-national

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

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

citizens (e.g. tourists) or businesses (e.g. foreign fishing vessels), which represent a redistribution of *value* from non-nationals to nationals.

Consumer and Producer surplus

In general, the analysis in this report is based on the microeconomic concepts of *consumer* and *producer surplus*. *Consumer* and *producer surplus* are net measures that capture the difference between the benefits and the costs of a particular good or service. *Producer surplus* is the benefit received by businesses, firms, or individuals who sell a good or service (the difference between the price that a producer is able to sell his/her goods for, compared to the minimum price they would be prepared to accept, which is computed as the surplus between the price they receive and their cost of production). *Consumer surplus* is the benefit received by individuals who purchase or freely enjoy a good or service (the difference between the benefit they obtain from consuming a good/service and the price paid for it, which is computed as the surplus between a consumer's maximum willingness to pay for a good and its market price). For market transactions, *producer surplus* is synonymous with *value-added* or *profit*.

Willingness-to-pay and willingness-to-accept

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

Total economic value

The *total economic value* of an *ecosystem* service includes all the net benefits humans receive from that *ecosystem* service. *Total economic value* (TEV) is a quantification of the full contribution ecosystems make to human wellbeing. *Total economic value* includes market and *non-market values* (i.e., *direct use value*, *indirect use value*, and *existence* or *non-use value*), and therefore represents the full benefit humans receive from *ecosystem functions*.

In practice, TEV is nearly impossible to calculate because the data required are rarely available. For example, fisheries resources offer benefits to those who harvest and sell seafood products (producers), as well as those who consume seafood products (consumers). The *total economic value* of the fishery is a sum of the producer and consumer benefits. However, consumer benefits are difficult to estimate and, in the case of export products, they accrue to individuals distant from the natural resource. Producer benefits alone are commonly used to estimate the *value* of fisheries, as represented in this report. These estimates are therefore a lower-bound *value* which do not accurately represent the *total economic value*.

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

3.2 The economics of ecosystems and biodiversity (TEEB)

IUCN Oceania has already undertaken a similar study in Fiji, Kiribati, Solomon Islands, Tonga, and Vanuatu under its MACBIO Programme. These national reports on marine and coastal *ecosystem services* follow the approach for assessing *ecosystem services* developed by the TEEB initiative (The Economics of Ecosystems and Biodiversity; www.teebweb.org). The TEEB approach comprises six steps:

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

The stakeholder workshop and consultations helped to identify specific applications of the economic *valuation* in Samoa, including which policy issues could be supported by more information about the *values* of *ecosystem services* (TEEB Step 1). The policy issues identified by stakeholders covered a wide range of topics but given the resource constraints, including those of time amidst the COVID crisis, conducting a detailed marine economic service *valuation* for every policy context identified was not viable.

It was therefore decided to conduct a more generic marine *ecosystem service valuation* which could be used, in whole or in part, to inform a range of existing and potential policy and decision-making situations in Samoa. The SUMA workshop, consisting of many focus-group discussions and individual consultations, together with existing documentation and literature, helped identify the most relevant *ecosystem services* for Samoa (Step 2).

Steps 2–6 were conducted by an IUCN consultant with in-country staff, following the approach of the TEEB initiative. TEEB encourages economic *valuation* practitioners to engage with stakeholders to identify needs and policy applications for the *ecosystem service valuation*, as well as developing methods for *valuation* that meet those particular needs, while also ensuring the data provided are useful and relevant.

A methodological guidance document (Salcone, *et al.*, 2016) developed in consultation with the country-based research teams during the MACBIO implementation, provided a guide to ensure as consistent-as possible treatment across all the Pacific Island study sites.

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

3.3 Applications of marine ecosystem service valuation

There are three main categories of applications of *ecosystem service valuation*:

1) to enable rational decision-making, via cost-benefit analyses or other analyses of trade-offs in management decisions;

2) as a technical tool to set prices for protecting resources or compensation for *ecosystem* damage; or

3) as general information to raise awareness about the human benefits of healthy ecosystems and support policy and governance that manage resources from a social equity perspective (Mermet, *et al.*, 2014).

The third application can lead to full integration of the benefits of ecosystems into national accounting (natural capital accounting). National-scale *ecosystem service valuation* is applicable mostly to this category - general information for planning and advocacy.

4. Literature review

This section briefly reviews *ecosystem services valuation* studies conducted in Samoa and the Pacific region, mainly through a survey of reports and publications from the relevant Samoan government departments, regional institutions, databases, and libraries. While the survey found numerous journal articles and reports on *ecosystem valuation* studies elsewhere, only a few studies on Samoa existed, including a more general economic analysis of Samoa's natural resources and a few global studies which encompassed assessments in Samoa.

In 2014 the German Agency for International Cooperation (GIZ) funded IUCN to publish five country reports on marine *ecosystem service valuation* in collaboration with the Secretariat for the Pacific Regional Environment Programme (SPREP), under the MACBIO project. These reports followed the Economics of *Ecosystem* and Biodiversity (TEEB) approach for Fiji, Solomon Islands, Vanuatu, Tonga, and Kiribati. The main objectives of the studies were to help countries identify, quantify and *value* their marine resources and *ecosystem services*, and identify any gaps for policy direction.

A reference guide to the *values* of Pacific Islands' marine ecosystems was compiled using the Marine Ecosystem Services Partnership (MESP) library of *valuation* studies (Jungwiwattanaporn & Pendleton, 2015). The guide summarizes estimates of *ecosystem service values* from various studies conducted in PICTs including the only one study completed in American Samoa (Spurgeon, *et al.*, 2004) and one study in Samoa (Mohd-Shahwahid, 2001). The guide provides useful links to websites with *valuation* studies and describes the application of these estimates in policy decision making.

A guidance manual outlining the methodological aspects of economic *valuation* of marine and coastal *ecosystem services* in the Pacific was also produced (Salcone, Brander, & Seidl, 2016). The national studies, reference guide, and the manual, provide a useful background to the TEEB methodology and for any comparative assessment work.

A general assessment of the *economic contribution* of the ocean resources to the economies of the PICTs was produced by Seidel and Lal (Seidel & Lal, 2010). This study extrapolated empirical data from available case studies and estimated the annual TEV for coral reefs and mangroves to be about US$3.8 billion or US$73,300 per km per year, and US$3.9 billion or US$546,100 per km per year respectively for the entire PICTs. These estimates included indirect and *non-use value*s of US$1.6 billion per year for mangroves, and indirect and *non-use value*s for coral reefs of US$1.3 billion annually, relating to coastal protection, biodiversity and amenities (Seidel & Lal, 2010, p. 10). The *Gross value* Product of tourism and fishing to the economies of PICTs was estimated at US$2.27 billion for tourism and US$1.04 billion for fishing (Seidel & Lal, 2010, p. 8).

In 2001 and 2008, the Asian Development Bank (ADB) commissioned studies to quantify the *economic benefit* of the fisheries sector of PICTs (Gillett & Lightfoot, 2001), (Gillett, 2009). In 2014, the Secretariat of the Pacific Community (SPC) and the Australian Department of Foreign Affairs and Trade (DFAT) commissioned an update of the earlier studies and surveys (Gillet, 2016). This study focused on macroeconomic aspects of the fishery such as production, contribution to GDP, access fees, government *revenue*, exports, employment, and contribution to nutrition. The study estimated the total annual harvest of fish and aquaculture for Samoa in 2014 as 11,276 million tonnes, with a *value* of SAT $83, 522,737: contributing to 3.5% of GDP for Samoa (Gillet, 2016, p. 222).

A global study using data from social media and crowd-sourced data sets estimated and mapped two distinct components of reef *value*s: a 'reef adjacent' *value* and 'on-reef' *value*s. Tourism *value*s were estimated as a proportion of the total visits and spending by coastal tourists within 30 km of the reefs. Reef-adjacent *value*s were set as a fixed proportion of 10% of this expenditure. On-reef *value*s were based on the relative expenditure of dive shops and underwater photos in different countries.

The study concluded that 30% of the world's reefs are of *value* to the tourism sector, with a total *value* estimated at nearly US$36 billion, or over 9% of all coastal tourism *value* in the world's coral reef countries (Spalding, et al, 2017). A total of 80 countries and territories with greater than 50 km^2 of reef and total reef related expenditure of over US$10 million per year were part of the study; Samoa was amongst one of the countries. The study estimated the mean *value* of reef for Samoa as US$31,089 km^2, and reef visitor expenditure as 9.65% of total tourism expenditure (Spalding, et al, 2017).

The first attempt to *value ecosystem services* in Samoa was done in 2001 (Mohd-Shadwahid & McNally, 2001). The study focused on the *valuation* of the terrestrial and marine resources of Samoa. This study was commissioned by the government of Samoa in 2000, with the aim of integrating biodiversity conservation with planning and policy under the Samoa NBSAP. The TEV of marine resources was estimated to be SAT$18.5 million per annum (SAT$68.82 million in 2019 dollars) or 2.7% of GDP. The critical attractions for the tourism industry were estimated to be SAT$1.74 million per annum or (SAT$6.44 million in 2019 dollars).

The overall TEV included climate *regulating services*, nutrient cycling and biological control as contributing towards global benefits. The TEV from forestry and fisheries was estimated to be SAT$232.5 million per annum or about 29% of GDP. The *value* of the marine resources including their direct use, ecological functions and cultural *value*s was estimated to be SAT$226 million per annum and accounted for 97.21% of the total TEV (Mohd-Shahwahid, 2001, p. 46).

An economic *valuation* of mangroves of the Safata District of Samoa was carried out in 2014 under the IUCN MESCAL project (Ram-Bidesi, *et al.*, 2014). The objective of the study was to solicit support for effective management of mangroves to reduce risk and vulnerability and support adaptation to climate change. A comprehensive socio-economic survey of villages in the Safata district was conducted and combined with secondary data. The direct use of mangroves for provisioning services such as the supply of fish and invertebrates, timber, firewood, and medicines was estimated to be about SAT$7,848 per ha per year to SAT$16,331 per ha per year. The average *value* per ha of mangroves was estimated to be SAT$140,419 or US$56,167.90 ha per year (Ram-Bidesi, *et al.*, 2014).

A 2018 study (Himes-Cornell, *et al.*, 2018) argues that mangrove *valuation* literature is not yet robust and lacks estimates of many *ecosystem services*, including cultural *ecosystem services* such as spiritual and aesthetic *value*s. *Value*s are themselves very context specific and can change greatly from one community or context to another, depending on their unique ecological, economic and social context. A summary of the literature on mangrove *valuation* shows that *value*s range from as low as US$5.75 per ha per year to US$414, 441 per ha per year (Himes-Cornell, et al 2018: supplementary materials).

The study recommends placing more weight on collecting primary data to improve accuracy and relevance. Ram-Bidesi, *et al.* (2014) noted that mangroves in Samoa were threatened, as only about five species were found, of which only two species dominated. The occurrence of mangroves in Samoa marks the eastern limit of the Indo-Pacific mangrove distribution. In terms of the importance of *ecosystem services*, such as fisheries to the Samoan household and economy, the notable studies include (Gillett, 2016; Gillett, 2011; Gillett, 2009; Gillett & Lightfoot, 2001; Tiitii, Sharp, & Ah-Leong, 2014; Vunisea, *et al.*, 2008; Ministry of Agriculture & Fisheries, 2018; Ministry of Natural Resources and Environment, 2015).

This report aims to present information used to identify the *economic value*s of marine and coastal ecosystems. Where possible, the report applies a survey of the current state of knowledge as a first step towards accounting for marine natural capital, and as a *baseline* on which more detailed *valuation* studies can be built. However, the methods that can be used to measure and quantify *economic benefit*s are varied, and the resultant *value*s can rarely be compared directly; rather they should be *evaluate*d on a case-by-case basis.

Useful references include Summaries of Marine *Ecosystem Service Valuation* Studies in the Pacific (Jungwiwarranaporn & Pendleton, 2015) and the Economic *Valuation* of Marine and Coastal *Ecosystem services* in the Pacific: guidance manual (Salcone, *et al.*, 2016). Additionally, a more detailed assessment is available in the Common International Classification of Ecosystem Services (CICES), which is developed in the context of work on the System of Environmental and Economic Accounting (SEEA) led by the UN Statistical Division (Haines-Young & Potschin, 2018). The following section outlines the methods used for obtaining data and information.

5. Methods

The methods and data requirements for estimating the *value* of marine and coastal *ecosystem services* are provided in Salcone, *et al.* (2016), which is a methodological guidance manual created in consultation with country-based research teams and other Pacific resource economists under the MACBIO project.

The report mainly relies on secondary data sources. Government staff and other relevant parties in Samoa collaborated on answering questions, supplying data and additional information, and by identifying data gaps (TEEB steps 1–4). The contributors also identified relevant in-country policies, plans, strategies, and other marine resource management tools.

5.1 Overview of estimation methods

This study identified seven key marine and coastal *ecosystem services* described and *value*d below:

1. Subsistence fisheries;
2. Commercial fisheries;
3. Minerals and aggregates;
4. Tourism and recreation;
5. Coastal protection;
6. Carbon sequestration;
7. Research, management, and education

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

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

Unless otherwise stated, all monetary *values* have been converted to 2019 US dollars (US$) and Samoan Tala (SAT$). Currencies are converted using the most appropriate method to facilitate comparison of the benefits or costs. The *value* of export goods was typically converted to USD and then inflated using a US dollar *inflation* index. Local income and expenditure figures were updated using the World Bank Consumer Price Index (CPI) for Samoa. Where appropriate, international seafood products were inflated using the Food and Agriculture Organization (FAO) Fish Price Index. Throughout the report, an **exchange rate of US$ 1 =SAT$ 2.63** has been used.

5.2 Secondary data sources and quality

This study uses existing sources of data to analyse *ecosystem* service *values* and to identify data gaps. Secondary data were obtained from government divisions, in particular the Fisheries Division, Bureau of Statistics, Ministry of Natural Resources and Environment, and the Samoan Tourism Authority. Data sources from the Government of Samoa were the 2018 Statistical Abstract, the 2014 Household Income and Expenditure Survey, and the 2020 Budget Statement.

The Fisheries Division provided data records for fisheries and estimates of tuna harvest; additional fisheries data were obtained from reports by the SPC, the Pacific Islands Forum Fisheries Agency (FFA) and the Western and Central Pacific Fisheries Commission (WCPFC). Other reports prepared by the Asian Development Bank , the World Bank, Commonwealth Secretariat and the FAO were also used. Additional data were obtained from academic studies and project reports (such as the IUCN MESCAL and MACBIO programmes). The validity and accuracy of these secondary data, which vary among sources, is described following the identification, quantification, and *valuation* of each *ecosystem* service.

Where no other sources of data are cited, the authors used their own subject-matter expertise of Samoa supported by in-person consultations with Samoan authorities conducted by the lead consultant and Project Manager.

5.3 Data gap analysis and synthesis

A major focus of this research effort was to identify data gaps and weaknesses that prohibited the accurate *valuation* of marine and coastal *ecosystem services*. The importance of this exercise should not be understated. This report encourages and supports the use of *ecosystem service valuation* in national planning and policymaking, but in many instances, a true *economic value* of the human benefits of ecosystems could not be estimated due to a shortage of ecological or socioeconomic information. These data gaps are described where *ecosystem services* are quantified in Chapter 6.

Fisheries, tourism, carbon sequestration, aggregate mining, coastal protection and research and management benefits are estimated based on actual data from Samoa, where it is available. The definition of coastal fisheries is taken from the Samoa Coastal Fisheries Management and Development Plan (Secretariat of the Pacific Community, 2013). To avoid double-counting, this report discusses the catches of all tuna and tuna-like species under the offshore fisheries category, while bottom fishing is discussed under the coastal commercial section. Some general connections are drawn to other countries in the region in relation to tourism, coastal protection, and cultural *values*. The following chapter discusses the results of each of the *ecosystem services* identified for Samoa.

6. Results

This section includes the identification, quantification, and where possible, *valuation* of Samoa's most significant marine and coastal *ecosystem services* based on the human activities and livelihoods related to the *ecosystem services*. The first subsection for each *ecosystem* service - **Identify** - describes the *ecosystem* service and the relation between the ecological or biological processes of that *ecosystem* (*ecosystem functions*) and its human benefits (the *ecosystem services*).

The second subsection - **Quantify** - describes data that illustrate the magnitude of the service, either in monetary units or ecological measures and *evaluates* data gaps. Where sufficient data could be collected, the third subsection - **Value** - presents the *economic value* of the *ecosystem* service. The *value* represents a quantification of human benefits in terms of local monetary currency. The next subsection considers the **Sustainability** and **Distribution** of *ecosystem* service benefits.

It is important to understand whether human benefits can be maintained, or if they are expected to decrease because of unsustainable resource use or management practices. It is also necessary to recognise who receives the benefits from the ecosystem, whether poor or wealthy households, government, visitors or foreign nations. The **Uncertainty** of each *value* estimate is also discussed in this section. The following paragraphs firstly describe the context of the key ecosystems supporting fisheries in Samoa, prior to elucidating the services provided by them. The main Samoan fishing grounds include coral reefs, mangroves, seagrass, seamounts, lagoon and the open ocean ecosystems.

The fisheries sector in Samoa is divided into two categories: coastal and offshore. The coastal fisheries is further divided into coastal commercial and coastal subsistence, while the oceanic, or offshore fishery mainly targets tuna and tuna-like species. Coastal subsistence fishing refers to the harvesting of fish and other marine products for household consumption, given as gifts, or exchanged with other goods and services by fishers without any monetary transactions, while the coastal commercial catch is mostly destined for sale at the local markets. This distinction is sometimes indistinct, as fishing trips may include commercial, subsistence and recreational activities. Fishing is thus characterised by the habitats of coastal reefs, outer-reefs, lagoon, mangroves and open ocean (Tiitii, Sharp, & Ah-Leong, 2014). Table 3 provides a summary, extracted from various sources, of the fishing grounds.

Table 3: Size of Land and Marine Areas of Samoa

Area	Size	Reference
Land Area	2830 km^2	(Samoa Socioeconomic Atlas 2016)
Marine Area	120,000 km^2	(Paeniu et al 2015)
Reef Area	490 km^2 (49,000 ha)	(Govan et al, 2009); (Ah-Leong & Sapatu, 2009)
Coastline	403 km	(Govan et al, 2009)
Reefs at Risk	95%	(Paeniu et al, 2015)
Mangroves	464 km^2 752 ha 752 ha 374 ha	(Spalding *et al.*, 2010) (Siamomua-Momoemausu, 2010) (Saifaleupolu T. S., 2015) (Percival, 2018); (Government of Samoa & Conservation International, 2019)
Marine Managed Areas	109	(per. comm: A.Taua PFO, Fisheries Division, 6 March 2020)

As the foundation for food webs, coral reefs support an incredible diversity of fish. Some 991 fish species have been recorded in the wider Samoan Archipelago, of which at least 890 are shallow reef-dwelling species (Spalding, *et al.*, 2001). Fisheries statistics show that 86% of all fishing occurs in the reef and inshore areas, which also strongly correlates to the location of diverse marine species and sensitive habitats (Ministry of Natural Resources and Environment, 2015, p. 19; Ah-Leong & Sapatu, 2009). For example, Gillett (2014) notes that subsistence fishing in Samoa makes use of about 500 species, hence the term 'tropical multi-species fisheries' is often used to address the difficulty of managing such an heterogeneous array of species. Both subsistence and commercial fishers target species found in reef areas such as groupers, snappers, lobsters and sea cucumbers, all of which directly rely on the reef for spawning and habitat.

The status of coral reefs in Samoa and fisheries associated with coral reefs is discussed in various reports (for example see Skelton, *et al.* 2002; Samuelu-Ah Leong & Sapatu, 2009; (Chin, *et al.*, 2011; Sandin, *et al.*, 2017; Ziegler, *et al.*, 2018 & Ministry of Natural Resources and Environment, 2015). The two socio-economic assessment reports on fisheries in Samoa provide some site specific data and information on catch rates and yields of reef fisheries, biomass and ecological changes of coastal ecosystems (Vunisea, *et al.*, 2008 & Tiitii, *et al.*, 2014).

Mangroves are key influences on nearshore fisheries production. Due to the high abundance of food and shelter and low predation pressure, they form an ideal habitat for a variety of animal species during part or all of their life cycles. Mangroves may function as nursery habitats for commercially important crabs, prawns and fish species, and support offshore fish populations and fisheries (Nagelkerken, *et al.*, 2008). A UNEP report notes that the annual economic value of mangroves, according to the cost of products and services they provide, has been estimated to be between US$200,000 to US$900,000 per ha, while the range of reported costs for mangrove restoration is US$225 per ha - US$216,000 per ha (UNEP, 2006).

The physical and geographical characteristics of mangroves in Samoa are described in detail by Schuster (Schuster, 1993). The three largest mangrove areas in Samoa are the Vaiusu Bay Mangrove area (closer to Apia) and the Satoa/Sa'anapu and Le Asaga Bay mangrove areas located on the southern part of Upolu. Saifaleupolu (2015) noted the size of mangroves in Samoa to be about 752 ha, while (Percival, 2018) stated that the current total area of mangroves in Upolu and Savai'i is 374 ha. Given the concerns raised about mangrove degradation (Boon, 2001; United Nations

Environment Programme, 2006; Ram-Bidesi, *et al.*, 2014 & Saifaleupolu, 2015), it is more likely that the current mangrove area is on the decline and closer to an estimated 374 ha (Percival, 2018).

The direct use of mangrove ecosystem services, such as provisioning services from the supply of fish and invertebrates, timber, firewood and medicine, was estimated to be about SAT$7,848 to SAT$16,331 per ha per year (US$3,139.29 to US$6,532.30 per ha per year) (Ram-Bidesi, *et al.* 2014). This estimation can be compared to the mangrove fisheries use values of US$4,844 per ha per year in Fiji estimated by Sisto (Sisto, 1999), giving an equivalent of US$6,883.32 per ha per year in 2014 prices.

The role of seagrass and seagrass habitats depends on the location, habitat type and the nature of the adjacent environment (Brodie & N'Yeurt, 2018). Whenever seagrasses colonize marine sediments, they profoundly affect the physical, sedimentological, physio-chemical and biological characteristics of the area (Larkum,*et al.* [eds.] 2006). As ecosystem engineers and habitat formers, seagrasses provide important functions for marine ecosystems and contribute to human wellbeing through providing a number of benefits (Borger & Piwowarczyk, 2016).

Seagrasses provide foraging and refuge habitats for exploited species, and also create a trophic subsidy to fisheries in adjacent and deep water habitats. They are important food sources for many herbivorous fish species, marine turtles and invertebrates such as sea cucumbers. Seagrass meadows also attenuate wave energy, and thus contribute to coastal defense and erosion control, while also supporting water purification and nutrient recycling. They achieve their high values by providing a wide variety of ecosystem services (Nordlund, *et al.* 2016). Dewsbury, *et al.* (2016) argues that most techniques to value seagrass do not consider the actual ecological drivers behind the economic services they provide. They argue that linking ecological structure and function to all associated ecosystem services is essential for accurately estimating their monetary value, thus highlighting the need to improve linkage of indirect use values to market goods and services.

In Samoa, three species and one sub-species of seagrass have been recorded (Skelton & South, 2014; (Government of Samoa and Conservation International, 2019): i.e. Halophila ovalis, H. ovalis ssp. bullosa and Syringodium isoetifolium. There is insufficient information on the areas covered, biomass and richness of seagrasses in Samoa. However, the main threats to seagrass health are known to be sedimentation from land-based sources and sand dredging (Ministry of Natural Resources and Environment, 2013).

There are several national level estimates of the value of fisheries (see Gillett & Tauati, 2018; Gillett, 2016; Gillett 2014; Lingard, Harper, & Zeller, 2012; Gillett, 2009, and Gillett & Lightfoot, 2001). Lingard, *et al.* (2012) use a consumption based approach, which links historical information with current patterns of marine resources to create a time series dataset of total marine fisheries catch from 1950 to 2010. The study showed that catches reported by FAO were 2.8 times lower than those reconstructed by Lingard and others. The reconstructed catches included estimates of under-reported subsistence and artisanal catches, by-catch and discards. In addition, there are three socio-economic fisheries studies (Passfield, *et al.*, 2002; Vunisea *et al.*, 2008) and (Tiitii, *et al.*, 2014) that are useful for estimating the coastal commercial and subsistence catch and value. The following sections provide discussions on the key types of fisheries in Samoa before assessing the values.

6.1 Subsistence fisheries

Subsistence fishing occurs when fish is consumed by the fishers or their family, given as a gift, or bartered locally (Kronen, *et al.*, 2007). Bell notes that the high consumption of fish in many PICTs underscores the vital contribution of fish to food and nutritional security (Bell, *et al.*, 2009). Bell's observation still remains valid despite the changing nature of fisheries and the coastal environment. Subsistence fishery contributes significantly to household diets and therefore has substantial *economic value* (Gillett R. , 2009). Several studies have highlighted the importance of subsistence fisheries in Samoa (Gillett & Tauati, 2018; Bell, *et al.*, 2009).

Under the Samoan constitution, the land below the highwater mark is owned and controlled by the government, while under the customary law, waters adjacent to a village are considered part of the land controlled by that village (Techera, 2006). Therefore, every community member in a coastal village has access to coastal fishing grounds.

6.1.1 Identify

Besides Gillett & Tauati, 2018; Gillett, 2011; Gillett, 2009; and Bell, *et al.*, 2009, only a few studies have examined the nature and contribution of subsistence fishery to the fisheries sector and the Samoan economy. Although formal

Figure 4: Women engaged in subsistence fishing in coastal fishing grounds of Satoa Village

fisheries employment is male dominated, women and children play an active role in the subsistence fishery. Subsistence fishing methods may include the use of nets, seines and spear guns, small-scale trolling, and fishing near FADs, using vessels such as alia catamaran and canoes (Tiitii, *et al.*, 2014).

In addition to fin-fishing, men dive for invertebrates such as lobsters, trochus, giant clams and sea cucumbers. Women and children on the other hand collect many species of shellfish, sea cucumbers, sea urchins, octopus, crabs and seaweeds near the shoreline, lagoon and reef top areas at low tide using simple gear, like knives, sticks and bare hands. Figure 4. shows women fishing for their daily food needs. These types of subsistence activities are frequently underestimated or missing from national statistics (World Bank, 2000). While there is still a high per capita consumption of fish and invertebrates in Samoa, there is a shift towards a more cash-based economy where some fishers are targeting fish for household consumption as well as for sale, as opposed to traditional subsistence and communal sharing (Tiitii; *et al.*, 2014).

6.1.2 Quantify

There have been several attempts to estimate coastal fisheries production in Samoa over the years, which Gillett (2018) notes have produced a large range of results. These variations could be explained by methodological differences, the time period of the study, the scope of the study and coverage of sites, among other things. Some attempts to quantify the coastal fisheries sector with reference to subsistence fishery are summarised below.

The FAO estimated that fish contributed an average of (12.5 g/capita/day) or 14.8% of protein in Samoan diets in 2016 (23.5% of all animal protein) (Food and Agriculture Organisation, 2019). The FAO Fishery Food Balance Sheet is based on fish production and consumption, imports, exports and excludes non-food consumption uses, to determine total fish and fishery products supply for human consumption. From 2012 to 2016, the per capita supply of fish in Samoa was 47.3 kg to 54.3 kg per capita per annum (FAO, 2014-2019). The FAO estimates are based on fisheries data provided by national governments. In Samoa, the Fisheries Division regularly collects data on local fish market sales but not on household production or consumption.

In Samoa, as in other Pacific Island countries, estimating the amount of coastal subsistence catch is complex, given the scattered nature of the fishery, irregular production patterns and the informal nature of the fishing operations. Gillett, for example, notes that the smaller the scale of the fishery, the less is known about the production levels, with quantitative information especially scarce (Gillett, 2011). According to the FAO data for Samoa in 2016, the total supply was 11,223 mt of which 3,616 mt was exports, 5,466 mt imports and 4,450 mt was for non-food use (FAO, 2019). This equates to an approximate 3,157 mt **domestic supply** of fish consisting of both coastal commercial and subsistence.

On the other hand, data from socio-economic household surveys found that fish and invertebrate consumption has been much higher than reported by the FAO. In 2000, a household fisheries survey conducted to determine production levels (Passfield, *et al.*, 2001) randomly selected villages on both islands to represent 20% of all Samoan villages. From the 8,377 households, 9,600 male fishers and 2,100 female fishers were recorded. Inshore fishing totalled 82% and 18% outside of the reef.

The annual average subsistence consumption of seafood was estimated to be 57 kg per capita, consisting of 44 kg of fish and 13 kg of invertebrates and seaweeds (Passfield, *et al.*, 2001). The study recorded overall consumption to be 9,971 tonnes with 7,169 tonnes caught by village fishers as coastal production. Using a weighted average market price of SAT$16.29 per kg, the *value* of coastal production was estimated to be SAT$60 million per year. Adding the *value* of fish exports of SAT$40 million, the *gross value* of Samoan fisheries was estimated to be SAT$100 million (Passfield, *et al.*, 2001).

The total coastal catch of 7,169 tonnes from the above study was used by Gillett (2016: 216) to re-estimate the *value* of the coastal fishery as SAT$45 million, with 2,876 tonnes being sold and given away and 4,293 tonnes used in home consumption.

Another socio-economic survey was conducted during June-September 2005 by SPC as part of the PROCFish[6] initiative to provide *baseline* information on the status of reef fishery for management purposes (Vunisea, *et al.*, 2008). Four sites were selected, based on specified criteria that included having an active reef fishery, being a representative of the country, and having diverse habitats. Thus results from the survey were specific to the sites in relation to fishing pressure, target habitats, species and fishing methods. Results from the survey are summarised in Table 4.

6 (PROCFish/C) – was the Pacific Oceanic and Coastal Fisheries Development Programme, an inshore fisheries research initiative of the SPC.

Table 4: Selected fisheries profile of study sites in 2005 fisheries survey

	Manono-Uta	Salelavalu	Vailoa	Vaisala
Total population	1997	1841	1756	1502
Average size of households	9	10	11	7
No of households (HHs)	146	180	200	170
% of households involved in reef fishery	98.5	83.3	100	81.3
Quantity of fresh fish consumed (kg/capita/year)	79.37	58.03	47.73	51.62
Quantity of invertebrates consumed (kg/capita/year)	4.09	4.26	8.52	14.76
HHs eat fresh fish they catch (%)	82.1	75.0	88.6	66.7
HHs eat fresh invertebrates they catch (%)	52.2	37.5	56.8	54.2
HHs eat fresh fish given (%)	59.7	27.1	50	29.2
HHs eat invertebrates given (%)	64.2	31.3	36.4	31.3
*Total catch invertebrates (N=63)	67.14 t/yr	40.67 t/yr	47.67 t/yr	53.75 t/yr
*Total catch finfish (N=115)	251.67 t/yr	142.33 t/yr	127.39 t/yr	90.15 t/yr
**Total fishing ground area (Km^2)	37.22	11.33	8.34	3.60

* Total catch of respondents
**Total fishing grounds include habitats: coastal reefs, lagoon, outer-reef, outer-reef passage and total reef
Source: extracted from (Vunisea *et al.*, 2008)

Based on Table 4, the average fresh fish consumption across the 4 areas was estimated to be 61.26 kg per person per year, with consumption of invertebrates 9.61 kg per person per year.

The survey noted that catch is also used as a means to pay for use of motorised boats, canoes and fishing gear if borrowed. It was also noted that in Manono-Uta, fish is also gifted to individuals, such as the village pastor, in cases where people are obliged to donate catch to church functions and to other families. Furthermore, income from fishing is often a mixture of barter and small-scale economic operations, as various community members are engaged in both commercial and subsistence activities.

Following the PROCFish survey, another socio-economic survey was conducted in 2006 to assess the socio-economic status of rural villages with regards to their fishing practices (see Mulipola, *et al.*, 2007). The survey was based on 939 households in 49 villages, representing 4.3% of the total population. 44% of the households were engaged in fishing and 40% indicated they received fish as gifts. The average per capita consumption was 59.4 kg per person per year. Total consumption was estimated at 10,508 mt, which also included fish bought locally and caught by fishers.

The *value* of subsistence fishery was estimated at $SAT84 million[7]. The survey also found that 41.7% of the households have fishers, with about 75% of fishers engaged in subsistence production. Canned fish consumption was estimated to be about 8,120 mt with a *value* of SAT$30 million (Mulipola, *et al.* 2007). The study noted the results of a creel survey done in 2003 by the Fisheries Division involving 112 villages, whereby questions focused on consumption to categorise fisheries into subsistence, commercial and artisanal. The survey estimated a presence of 11,700 fishers in Samoa, with total landings of 12,270 mt. About 17% of fishers were classified as commercial, 53% as subsistence and 25% as artisanal (Mulipola, *et al.*, 2007: 9).

In 2012, the European Union funded the Samoan Fisheries Division and SPC to conduct another socio-economic survey involving 100 villages using a 30% sample size. The results of the survey showed that the total finfish catch was 9,066 mt/year, with an estimated *value* of SAT$89 million. The estimated catch of invertebrates was 7,804 mt/year, with an estimated *value* of SAT$86 million (Tiitii, *et al.*, 2014). The study estimated the annual coastal catch, including commercial and subsistence, to be 16,870 mt, with a total *value* of SAT$175 million.

7 Using average market prices from the Fisheries Division Annual Report 2005 – 2006 of SAT$8.00 per kg.

The annual per capita consumption of finfish was 46.15 kg/per person per year, while the annual per capita consumption of invertebrates was 54.74 kg per capita, with canned fish consumption at 28.61 kg/per person per year. The study also noted that from 1999 to 2009, an average of 25% of households participated in fishing for both consumption and sales, while on average only 4% of households fished primarily to sell their catch (Tiitii, *et al.*, 2014:2). This implies that 71% of the fishers primarily fished for subsistence.

The Household Income and Expenditure Survey (HIES) conducted by the Samoa Bureau of Statistics provided general information on income and expenditure related to seafood production and consumption. Using the HIES 2002, Bell *et al.* (2009) estimated the annual per capita consumption of fish in Samoa to be 87.4 kg per person per year (Bell, *et al.*, 2009). Average consumption per capita in the rural areas was estimated to be 98.3 kg per person per year, while in the urban area it was 45.6 kg per person per year. Subsistence production contributed towards 79% of consumption in rural areas and 21% in urban areas (Bell, *et al.*, 2009).

Gillett (2009) adjusted the 2002 HIES data with population change and market prices, and estimated the 2007 coastal commercial production to be 4,129 mt with a *value* of SAT$ 51,240,890. Subsistence production was estimated to be 4,495 mt and *value*d using farm gate prices to be SAT$ 39,048,065. Gillett updated these coastal fisheries production and *value* estimates in 2016, in light of socio-economic changes, the tsunami in 2009 and a cyclone in 2012. Gillett (2016) estimated that the 2014 coastal fisheries catch was 10,000 mt, with a coastal commercial catch of 5,000 mt worth SAT$42.5 million. Using a 70% farm gate price of fish, the subsistence fishery of 5,000 mt was worth SAT$29.75 million.

In an up-dated report, Gillett (2018) makes reference to the 2014 estimates of commercial catch of 5,000 mt with a *value* of US$17,782,427 or (SAT$41,787,783.42 using 2014 prices) and subsistence catch of 5,000 mt with a *value* of US$12,447,669 or (SAT$29,251,378.13 in 2014 prices). These are the most recent estimates for Samoa, based on previous studies.

According to the HIES 2018 survey, 35.9% of household weekly expenditure was on food. Fish and seafood constituted 13.2% of the total food expenditure (Samoa Bureau of Statistics, 2020). The non-monetary sector of Samoa was estimated at SAT$312.58 million, equivalent to 14% of the GDP (Samoa Bureau of Statistics, 2020a).

Table 5. Working age population working for money or subsistence in Samoa in 2017

Source	Total	Urban	Rural
Working for money	41,142	9,939	31,203
Working for money without subsistence	1,481	334	1,147
Working for money with subsistence	39,661	9,605	30,057
Subsistence only	65,323	11,351	53,972
	106,465	21,290	85,175

Source: Samoa Bureau of Statistics 2020b: 37

A labour force survey in 2017 indicated that a large majority of the Samoan population, particularly in rural areas, are leading a semi-subsistence lifestyle remaining reliant on activities such as agriculture and fisheries to supplement their incomes and diets, despite a gradual shift towards a cash economy. This is partly due to people having access to customary land for cultivation, raising animals, and easy access to fishing grounds. Table 5 shows the different levels of dependence on subsistence economic activity.

The Bureau of Statistics notes that in 2020, 15,342 people were in formal employment,[8] 1,800 in the urban area and 13,541 in rural areas (Bureau of Statistics, 2020b). About 22,099 people reported to be engaged in subsistence food production, of which about 1,500 reported only to be fishing and collecting shellfish, mainly for home consumption (Bureau of Statistics, 2020b, p. 45). This number seems much lower than those reported in socio-economic fisheries surveys, where at least 12.5% of the adult population reported at least 3.5 fishing trips per week (Tiitii, *et al.*, 2014).

The price of inshore fish and other seafood at the local markets is collected through an ongoing market survey conducted 3 days a week at the Apia Fish Market, Fugalei Agricultural Market and Salelologa Market, whereas data for the Roadside Markets (from Apia to Faleolo) is collected once a week (Ministry of Agriculture and Fisheries, 2018). The estimated total annual market landings of major inshore seafood products are given in Table 6, while Figure 5 shows the processed sea cucumber sold in bottles as a delicacy in the Samoan diet.

8 According to the Bureau of Statistics (2020), informal employment is where employees do not receive any annual or sick leave benefits and pension contribution, or where labour regulations are not applied or enforced. Subsistence food producers are those above 15 years of age who engage in agriculture, rearing animals or fishing for household consumption.

Table 6: Total annual market landings of major inshore fisheries (2016 – 2017)

Group	Estimated weight	Estimated price SAT($)	Average price per kg SAT($)
Crustacea	3.13	80,571.74	25.76
Echinoderms	7.63	13,674.92	1.79
Finfish	113.96	1,370,738.74	12.03
Molluscs	13.14	33,791.11	2.57
Other	7.25	142,305.52	19.62
Processed	8.60	594,040.28	69.10
	153.71	2,235,122.37	

Source: MAF Annual Report 2016 - 2017

Figure 5: Fishers selling processed sea cucumbers at the Apia market

In estimating the *value* of coastal commercial catch, (Gillett 2009) used the market and roadside fish prices given by the Fisheries Division in 2008 as $12.41 per kg. This price was also used in Gillett (2016), while the average price for finfish as SAT$9.81 per kg and $SAT11.02 per kg for invertebrates was used by Tiitii, *et al.* (2014). Using the latest Fisheries Division price estimates, the average price of fish in 2016-2017 was SAT$14.54 per kg. Interviews with market vendors at the Apia fish market (13-15 March 2020) revealed that although prices varied, the likely average price for fin fish and fishery products was in the range of SAT$10 to SAT15 per kg. Gillett (2016) also noted the difference in fish prices at the market landings and those reported in the socio-economic surveys.

Subsistence fishing costs include fishing gear such as hooks and line, nets, spears, goggles, torch lights and boat and boat-related expenses, such as fuel and maintenance. The capital and variable costs must be subtracted from the *gross value* of harvest to determine the true *economic value* of subsistence fishery. Village level data on subsistence fishing costs has been difficult to find, given the focus of the household surveys on consumption.

Fishing costs were noted in the 2014 survey of the mangrove-related fishery in the Satoa District in 5 rural villages (Ram-Bidesi, *et al.*, 2014). While the study focused on mangroves as habitat, it included fishing activities conducted in the coastal areas as many of the coastal species have either indirect or direct dependence on the mangrove habitats at some stage of their life cycle. The annual average operating cost[9] including gear, ice and food was SAT$436.81 per fisher without a boat or canoe, while a fisher with a non-motorised boat or canoe had an annual cost of SAT$1,036.81 which included annual depreciation of the canoe or boat. Fishers with motorised boats had average weekly fuel costs of SAT$40, with a total cost of SAT$2,716.81.[10]

Fishers who harvest on reef flats and in mangrove areas at low tides had minimal fishing costs, which included such equipment as knives, forks and carry bags. Subsistence

9 42 weeks of active fishing were taken to represent annual operations while the rest of the period was regarded as "down-time" due to inclement weather, maintenance requirements and attending to other priorities.
10 Calculated from (Ram-Bidesi, et al 2015).

fishers are not paid a wage but their time has *value*. The *opportunity cost* of labour (such as average local wage rate) is subtracted from the *value* of the fish caught. Sometimes, this *value* can be negative, if fishers are earning less per hour than the typical wage rate or the minimum wage rate in the economy. Subtracting the *opportunity cost* of wage labour can be applicable in situations where wage-earning jobs are available to fishers, but in many instances, particularly in rural villages where there are no other employment opportunities, true *opportunity cost* for subsistence fishers does not exist (Salcone, *et al.*, 2015).

6.1.3 Value

The *value* of subsistence fisheries *ecosystem services* should be estimated from harvest data, multiplied by an appropriate price of equivalent protein, less the cost of subsistence fisheries as shown in the equation:

$$\text{Value (Benefit)} = (\text{subsistence harvest}_{kg} * \text{Price Protein Equivalent}_{\$/kg}) - \text{Harvest Costs}_{\$}$$

Protein equivalent in Samoa is predominantly canned fish, canned meat, chicken or fish and other seafoods bought from the market. Using market prices for equivalent seafood products would reflect the true replacement cost *value*, although in reality, households may choose to purchase lower-*value* products in place of the kinds of seafood they would normally catch.

The latest HIES (2018) was used to estimate the level of subsistence production, based on the consumption per capita of fish and seafood. The household expenditure data on fish and seafood indicates the amount of money people spend on these items in the rural and urban areas. The average annual expenditure per person on seafood, divided by the average market price of fish, results in the average per capita consumption of purchased fish and seafood.

A report by Gillett (2016) and (Gillett & Tauati, 2018) estimated that coastal fisheries in Samoa consist of about 50% as commercial and 50% as subsistence. Using HIES data could reveal the amount people spend on buying seafood from the market - the commercial component of the catch that is sold. Therefore, the average apparent consumption of fish and seafood per capita would be about twice the amount bought (50% consisting of purchased and 50% as subsistence).

The total annual expenditure of fish and seafoods (SAT$54,419,612) divided by the total population (199,430) and market price (SAT$10.00) multiplied by 2, gives the total annual per capita consumption of 54.58 kg per person per year. Likewise, the urban per capita consumption was determined using the urban population's annual expenditure (SAT$9,716,252) divided by the urban population (37,567) and market price (SAT$10.00) multiplied by 2, which gives 51.8 kg per capita.

The rural consumption per capita was 55.2 kg, using the annual rural expenditure on fish and seafood (SAT$44,703,360) divided by the rural population (1161,863) and market price (SAT$10.00) multiplied by 2. The per capita consumption therefore consists of fish and seafood bought, including canned fish, plus fish caught by fishers for their own consumption as subsistence. The per capita consumption multiplied by the respective populations results in the total quantity of fish supplied as 10,880.81 mt.

In a 2014 study, Tiitii noted that the proportion of the total per capita supply of fish consisted of 36% finfish, 42% invertebrate and 22% canned fish (Tiitii, *et al.*, 2014). Assuming a similar consumption pattern, given that the villages chosen for the study were representative of typical Samoan villages, this equates to 22% of canned fish or 2,394 mt. Therefore, the total supply of **domestic coastal fisheries** equals to 8,487mt, given half of this as subsistence (4,243.5 mt) and the other half coastal commercial.

Alternately, canned fish is the major component in fish imports, so subtracting imports of seafood (5,466 mt) (FAO, 2016) would also give an estimate of domestic coastal fisheries of 5,415 mt, of which half (2,707.5 mt) would be equivalent to the subsistence component. The estimated quantity of subsistence harvest can therefore be surmised as ranging from 2,707.5 mt to 4,243.5 mt c. Using the market price of $10.00 per kg (2018 prices), the *gross value* of subsistence fishery is estimated between SAT$27.08 million to SAT$42.43 million per annum.

The likely quantity of subsistence catch for 2019 can be extrapolated from these figures while also considering population and market price changes. Using the HIES 2018 to estimate subsistence consumption in urban areas (25.9 kg per person per year) and rural areas (27.6 kg per person per year), and the 2019 estimated urban and rural population (Samoa Bureau of Statistics, 2019), the subsistence catch can be estimated as **5,438.5** mt. Using the average market price of SAT$12.50 for finfish from the Fisheries Division Database, the *gross value* of subsistence fishery is estimated at $SAT 67,981,250.

However, if production of coastal fisheries has stabilised over the recent years as suggested by Gillett (Gillett, 2016, 2018), it is likely to remain around 5,000mt, and the likely *value* would be SAT$62,500,000 with adjustment of the market price (SAT$12.50) and population (200,874) (Samoa Bureau of Statistics, 2019). Therefore, the estimated *gross value* of subsistence fishery in 2019 would be between SAT$62,500,000 and SAT$67,981,250 or US$23,764,259 and US$25,848,384.

The cost of harvest needs to be deducted from these *gross value*s to determine the net benefit from subsistence fishing. However, cost estimates for coastal subsistence and commercial fisheries were unavailable from socio-economic surveys or any other reports. Estimated costs of fishing operations (Ram-Bidesi, *et al.*, 2014) were used to represent the likely estimates of fishing costs in Samoa, noting that fishing costs vary amongst fishers depending on their mode of operation, target species and trip duration. Fishers either fished with or without canoes or boats. The average cost of fishing ratio to *revenue* in the Satoa and Saanapu District was 23%. Subtracting these costs provides the net benefit of subsistence fishery of SAT$48,125,000 and SAT$52,345,562 or US$18,298,479 and US$19,903,255.

The estimate of 54.58 kg as average per capita fish and seafood consumption is less than the 87.4 kg per capita estimated by Bell *et al.* (Bell, *et al.*, 2009) and the 129.50 kg per capita estimated by (Tiitii, *et al.*, 2014). In comparison to Bell and others assessment of rural (98.3 kg) and urban (45.6 kg) consumption (Bell, *et al.*,2009), the above results show that subsistence consumption in rural areas (55.2 kg per person) has declined, but increased in urban areas (51.8 kg per person).

This could be due to those who are unemployed or engaged in informal employment in urban areas resorting to fishing as a means of obtaining food, while remittances sent to rural communities allow people easier access to cash to buy substitute food items. Additionally, canned fish and meat also contribute towards the diet of Samoans, as these items are becoming more convenient foods. For example, during ceremonial exchanges such as the *Fa'alavelave*, canned goods and non-perishable items are becoming more common due to increased monetisation[11] (Gove, 2017). However, a closer assessment of such trends needs to be investigated.

Alternatively, if the FAO estimate of 12.5 g per capita per day (FAO, 2018) is used, the average per capita consumption would be 45.62 kg per person per year. The FAO estimate is dependent on fisheries data which has been extracted from market surveys, supplied by the Fisheries Division. Market data has not been collected during the urban markets' busiest time on Sunday mornings from 5:00 am to 9:00 am. Given the resource limitations, extrapolations of market survey data for national estimates in recent times has not been available.

The variance in information provided from the different sources of data for the above measures illustrates the difficulty in quantifying this *ecosystem* service.

6.1.4 Uncertainty

There is wide variation in estimates of coastal fisheries catch when compared to coastal catch data reported in Fisheries Division Annual Reports. The socio-economic surveys give coastal catch estimates of about 75 times greater than the market and outlet (Gillett, 2016: 219). Gillett notes that the Samoan Bureau of Statistics relies on HIES data for macroeconomic estimations.[12] Even the *value* of HIES estimations are extrapolations of responses to questions about household expenditure on consumption and labour activity.

This report uses data from the most recent HIES (2018), socio-economic fisheries survey (2014) and Gillett (2014, 2016, 2018), the Fisheries Division market database and FAO (2017, 2019). A range is given for the subsistence production estimates to compensate for uncertainty about the quantity of production.

There is a paucity of data on fishing costs related to subsistence and artisanal coastal operations. Given the limitation, a second-best option was to use data from coastal fishing activities conducted in Samoa in 2014 that encapsulated all coastal fishing activities including reef fisheries, but focused on the mangrove fishery. Fishing costs were found to be highly variable and dependent on whether or not fishers used boats and canoes. The average cost was therefore used to determine the cost ratio of

11 Fa'alavelave – is a ceremony of major exchange during wedding, funerals and community functions. Given the communal culture, status comes from what an individual contributes to the community, rather than what they accumulate for themselves at each Fa'alavelave; it is expected that the host family gives more than it receives.

12 HIES – uses individual diaries completed by respondents in selected villages over a 2-week period, in the presence of enumerators, while the fisheries' surveys involve a general recall of fish caught and consumed.

harvest which varied between 15% (without boats) to 23% (with boats). Given the increasing use of canoes, boats, fuel, modern gear and equipment, higher maintenance costs and depreciation, the cost ratio of 23% was used because it was based on actual village socio-economic surveys. This is however slightly higher than the *value-added* ratio of 0.9 used by Gillett (2016) for subsistence fishery for Samoa, and lower than the 49% intermediate fishing costs used by Starkhouse (Starkhouse, 2009) for subsistence fishery in Fiji.

The price estimate of SAT$12.50 from the Fisheries Division Database is used to reflect the average price of finfish in the urban markets and outlets in Samoa. The average price of all major species categories in the Fisheries Database was not used because it did not reflect the true price of fresh seafood. The average prices would have been inflated by the relatively greater *value* of invertebrates but with very low volumes compared to finfish.

The data used for the *value* estimates provided above are the most current(2012 onwards). The harvest estimates lie within the range provided by Gillett and Tauati (Gillett & Tauati, 2018) of around 5,000 mt, but the *value* estimate is much higher due to the different approaches to *value*. Gillett's assessment is based on the farm gate price of catch, while the above estimation uses the updated market price as a replacement cost for substitute protein.

6.1.5 Sustainability

The sustainability of coastal fisheries depends on the area and quality of critical habitats relative to the level of exploitation. Many coastal finfish and invertebrates are associated with specific habitat types (coral reefs, seagrass, mangroves, lagoons). Coral reef habitats are generally expected to yield 3 mt of demersal fish per km^2 of reef habitat (Jennings & Polunin, 1996). Accounting for the status of coral reefs in the world, the MSY of coral reefs has been estimated to be about 5 mt per km^2 per year (Newton, *et al.* 2007). However, sustainable harvests from coral reefs may vary considerably depending on their condition and productivity. For example, reefs in Fiji with low impact from land-based activities have been estimated to provide sustained yields of at least 10 mt per km per year (Jennings & Polunin, 1996).

In a study of mangroves in Sri Lanka (Amarasinghe, 1996), yield estimates of fish, crabs, prawns and molluscs from mangroves ranged from 750 kg ha^{-1} yr^{-1} to 2500 kg $ha^{-1}yr^{-1}$ (Kallesoe, et al 2008). In a meta-analysis of mangroves (Salem & Mercer, 2012) the authors estimated that fishers produce an average of 539 kg ha^{-1} yr^{-1} with a maximum production of 2500 kg ha^{-1} yr^{-1}.

Given the limited size and number of species of mangrove ecosystems in Samoa, the lower *value* of 539 kg ha^{-1} yr^{-1} could be used to estimate the potential production. Within an estimated area of 374 ha of mangroves in Samoa, this equates to about 202 tonnes per year. With a reef area of 490 km^2 and productivity of 5 mt per km^2, the sustainable production would be around 2,450 mt per year. Although only a rough indicator of sustainable coastal production from reefs and mangrove habitats, this amount (2,652 mt) is very much lower than current harvest levels. A more in-depth resource assessment survey is needed to adequately ascertain the situation on the ground, with regards to levels of over-exploitation.

Data on reef resource use suggest declines in diversity and abundance of some species groups, (especially parrotfish) and demersal fish size (Chin, et al 2011). Some reefs have been affected by pollution and sedimentation, as well as Crown of Thorns starfish (COTs), cyclones and coral bleaching linked to increase in temperature due to climate change (Chin, et al 2011).

A variety of management initiatives have been established under the community-based fisheries management programme, whereby the Fisheries Division is working in collaboration with communities and CSOs and NGOs to ensure effective management and enforcement. These are further integrated into the broader community-integrated management plans under the leadership of the traditional chiefs and elders.

6.1.6 Distribution

The benefits from subsistence fishing largely accrue to households in Samoa. Subsistence fishing does not generate government *revenue* or foreign exchange, which means that it can be easily neglected in economic planning and policymaking. Despite the uncertainty in subsistence fishing data, the proximity of households to marine resources, and the limited income available to most Samoan households to purchase imported and/or processed foods, indicate that subsistence fishing is, and will continue to be, important to the wellbeing of Samoan families. This is particularly true for families close to nearshore lagoon, reef, and mangrove habitats accessible to fishing with minimal costs.

6.2 Commercial fisheries

This section evaluates the harvest of seafoods that are sold or exchanged via a monetary transaction. The EEZs of the Pacific Island countries are economically important to the region, and the largest supplier of global tuna as a source of animal protein. The extended reef and lagoon areas also support the provisioning of a wide variety of commercially high demand seafood such as lobsters, crabs, sea cucumbers and demersal fish.

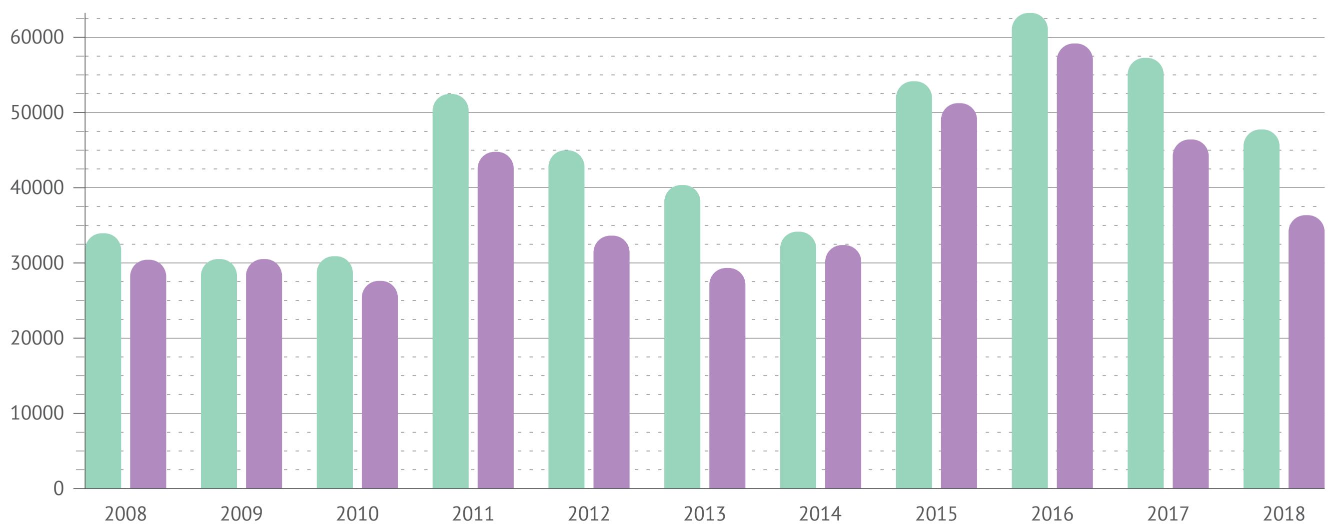
Commercial fishing in Samoa is divided into coastal and offshore fisheries (Gillett, 2016). Coastal fisheries occur in any reef, lagoon, mangrove, inter-tidal zones or other areas that have relatively shallow water and mostly have non-migratory fish and invertebrate species. 'Coastal fisheries' in Samoa is defined as any fishery conducted in coastal waters, lagoons, reefs, and outer-reef slopes, or seamounts in the Samoan EEZ (Secretariat of the Pacific Community, 2013).

Offshore fisheries occur in deepwater areas and open oceanic environments. A considerable amount of fishing takes place from the shore or in shallow waters, without the use of vessels. Where fishing vessels are used, they are generally small either non-powered canoes, dinghies, or punts with outboard motors. Larger vessels of 8m to 20m in length powered by inboard engines are mostly used for commercial fishing for demersal species beyond the reef slopes and trolling for tuna in the open ocean areas.

Under the Law of the Sea Convention (2000), countries can exclude others from fishing in their waters. Limiting access allows countries to earn a *resource rent*. Having extended jurisdiction authorises governments to exclude and/or regulate fishers and companies from harvesting fish in their EEZ. Fishers who are permitted to harvest seafood in the EEZ can capture this *resource rent*. When a country charges a licence fee for access to its EEZ, they are acquiring some of the *resource rent* earned by the fishers. This *resource rent* is a benefit to the country. The following paragraphs describes the role of commercial fisheries in Samoa in terms of its contribution to GDP, exports and employment followed by analysing the *value* in terms of *ecosystem services*.

The Bureau of Statistics estimates that the total output of fishing (subsistence and commercial) to be around SAT$ 36.4 million in 2018 (in constant 2013 prices). Figure 6 shows the *gross value-added* of the fishing industry from 2008 to 2018.

Figure 6: *Gross value* added by the fishing industry in Samoa from 2008 to 2018



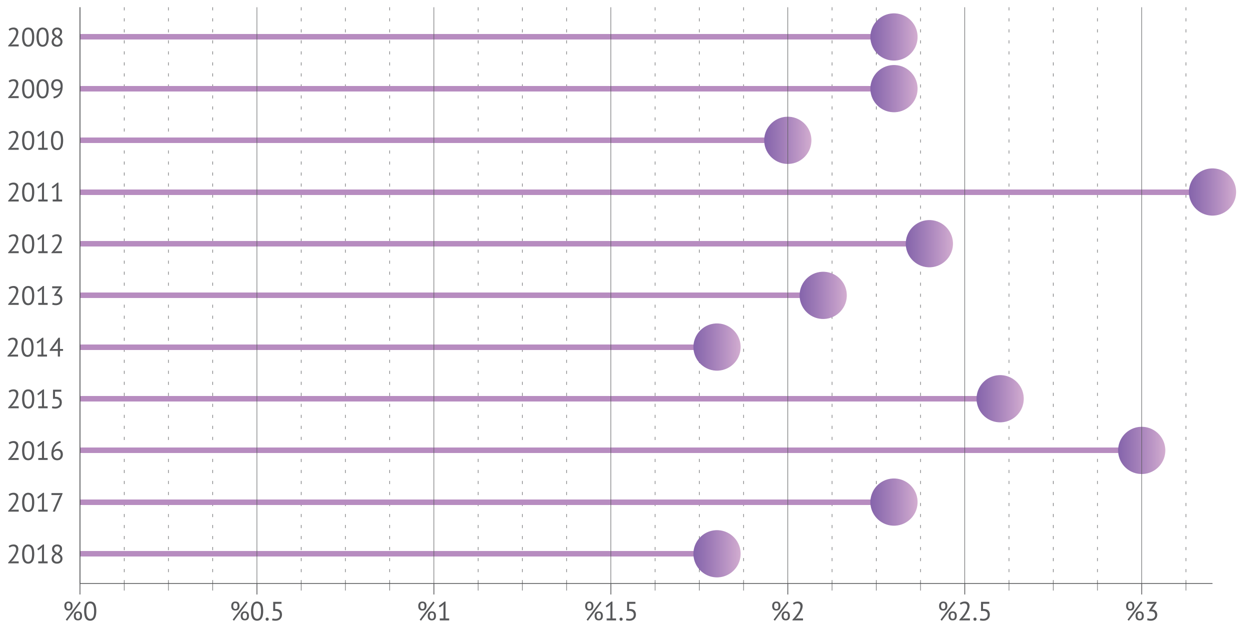
*Constant 2002 prices 2008 - 2013; constant 2013 prices 2013 - 2018

Source: Bureau of Statistics, Statistical Abstract: 2014, 2019

Value-added, which refers to the total output of the sector minus any *intermediate costs*, is used to measure GDP. Figure 7 shows that fishing GDP has fluctuated between 2008 and 2018, with increases in 2011, 2015 and 2016 and a steady decline in 2017 and 2018. Some of the major contributing factors for the fluctuations include: the 2007 global financial crisis, which led to an increase in import prices for goods such as fuel and food; the tsunami in 2009, preceding recovery by 2011. In 2015, an increase of 6.7% was noted mainly due to Samoa hosting major social events such as Commonwealth Youth Games, international rugby and preparations leading to national elections in 2016. The fishing industry contracted in 2018 due to changing weather conditions and extensive damage caused by cyclone and market access constraints (Bureau of Statistics, 2020).

While fishing is an important social and *economic activity* in Samoa, its actual *value* is not well reflected in the GDP. Figure 7 shows that fishing has contributed to between 2-3 % of GDP.

Figure 7: Fishing as a percentage of GDP in Samoa

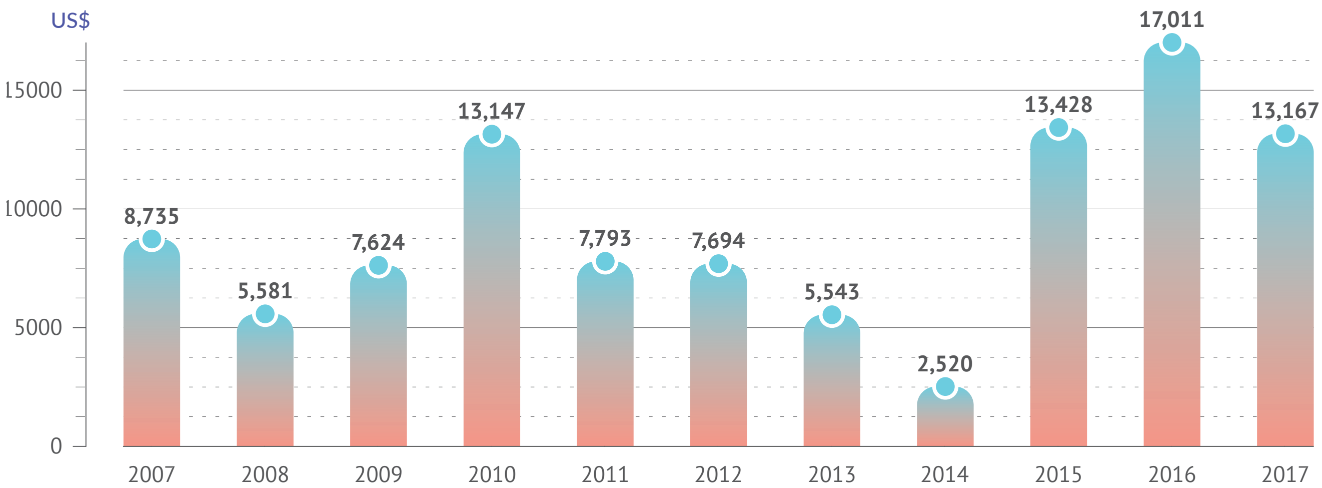


Source: Bureau of Statistics, 2014, 2020.

The Fisheries Department uses 2 categories for fish exports: non-commercial export and commercial exports. The non-commercial exports mainly comprise fish species from coastal areas, particularly lagoon and outer-reef slopes, including some processed seafood, which are mostly exported to New Zealand and Australia as passenger luggage. In the period 2016/2017, an estimated 4.7 mt of fish were exported overseas for family consumption (Ministry of Agriculture and Fisheries, 2018). Over the same duration, 4,000 tonnes of commercial tuna were exported, with a *value* of SAT$29 million. This consisted mainly of frozen albacore caught by foreign vessels for cannery in American Samoa (Ministry of Agriculture and Fisheries, 2018) and fresh chilled tuna exported to Japan as by-catch species consisting of wahoo and dolphin fish.

As fish exports are of major economic importance to Samoa, exports of tuna have been steadily increasing since 2015. In 2017, fish exports comprised about 11% of total commodity exports. This increased to about 28.4% in 2018 (Bureau of Statistics, 2020). Figure 8 uses FAO data to illustrate the trend in fish exports from Samoa. Even though the percentage contribution of fish to commodity exports has been rising, the *value* of exports shows that exports have been fluctuating due to changes in global fish prices.

Figure 8: Fish exports from Samoa in US$(000)



Source: FAO, 2020, 2014.

Table 7: No of Households by Fishing Habitat and Region in 2015

Region	No of fishing households	Inshore	Offshore	Freshwater
Samoa	5,943	5,533	872	377
Apia Urban Area	288	213	51	24
North West Upolu	1,175	1,125	98	12
Rest of Upolu	2,051	1,952	208	66
Savai'i	2,429	2,242	516	275

*A household can fish in more than one habitat

Source: Bureau of Statistics (2016)

In 2015, 5,943 Samoan households engaged in fisheries, representing about 21% of all households in the country (Bureau of Statistics, 2016). Table 7 illustrates the number of households by fishing habitat and region in 2015, highlighting that about 85% of these are engaged in inshore fishing only.

In 2015, 70% of the households did not sell any fish, only 3% sold all their catch (Bureau of Statistics, 2016). The following section discusses how the *values* of key commercial fisheries have been derived.

6.2.1 Coastal commercial fisheries

The composition of reef fish catches is extremely varied in time and location. The status of important fisheries resources in Samoa (including finfishes, crustaceans, molluscs, seaweeds, sea cucumbers, sea urchins, palolo and jellyfish) has been documented by Bell and Mulipola (Bell & Mulipola, 1995). Gosliner, *et al.* (1996) listed 50 hard coral species and Skelton and South (Skelton & South, 1999; 2014) compiled 198 taxa of marine plants and algae.

Commercial coastal fisheries include reef and lagoon fisheries and invertebrates sold in the domestic markets. However, domestic, artisanal and commercial fisheries also include deepwater bottom fishery, trolling and small-scale tuna longlining, but are categorised as offshore fisheries in the Fisheries Division reports because the fishing activities are conducted on the outer-reef slopes and the open oceanic environments.

6.2.1.1 Identify

A large volume of the marine products sold at the domestic fish markets in Samoa have been reef and lagoon fish and invertebrates caught by small-scale artisanal fishers in coastal areas. As noted in the previous section, most Samoan households involved in fishing consume most of their catch and sell any surplus. However, the need for cash income motivates fishers to sell for income first and consume only what is not sold (Tiitii, *et al.*, 2014). Reef fish and invertebrates are harvested in Samoa by harvesting at low tides, handlining (from shore or boat), use of hand nets in shallow waters, diving, and spear fishing. Major markets in the Fisheries Division surveys are the Apia fish market, Fugalei Agricultural market, Salelologa market and roadside markets from Apia to Faleolo. Informal sales that occur in villages are not included.

6.2.1.2 Quantify

Finfish generate the most volume and *value* of the major seafood groups. In 2017 finfishes generated more than 60% of the volume and 50% of the *value* of seafood targeted domestically (Tiitii, *et al.* 2017). Finfish were either sold individually at an average price of SAT$12.50 per kg, or as a string of fish (13-15 fish), with an average weight of 4 kg/string, sold at SAT$30. Most common finfish recorded were from the families *Scaridae*, *Lethrinidae*, *Mugilidae*, *Carangidae*, *Scombriade*, *Lutjanidae*, *Siganidae*, *Mullidae*, *Serranidae and Acanthuridae*. Processed seafood, including raw bottled species or cooked species of sea cucumbers, accounts for 27% of estimated *value* and 4.5% of volume (Tiitii, *et al.* 2017). Crustaceans include lobsters and crabs, echinoderms (sea urchins), molluscs (bivalves and octopus). Sea grapes and palolo make up the 'other group' category.

The total estimated volume of coastal fisheries' products landed and traded domestically in 2019 was 96.42 mt *valued* at SAT$1,883,501.74, compared to 123.29 mt *valued* at SAT$ 2,102,962.97 in 2018 (Fisheries Division database). Figure 9 shows the market landings from 2008 to 2019 and their respective *values*. Figure 10 shows the major categories, while Figure 11 shows the respective average prices of the market landings. However, market landings are dominated by finfish, which has an average price ranging from SAT$10 per kg to SAT$20 per kg., whereas processed seafoods are of small quantities with an average price of SAT$60 per kg and crustaceans at SAT$25 per kg.

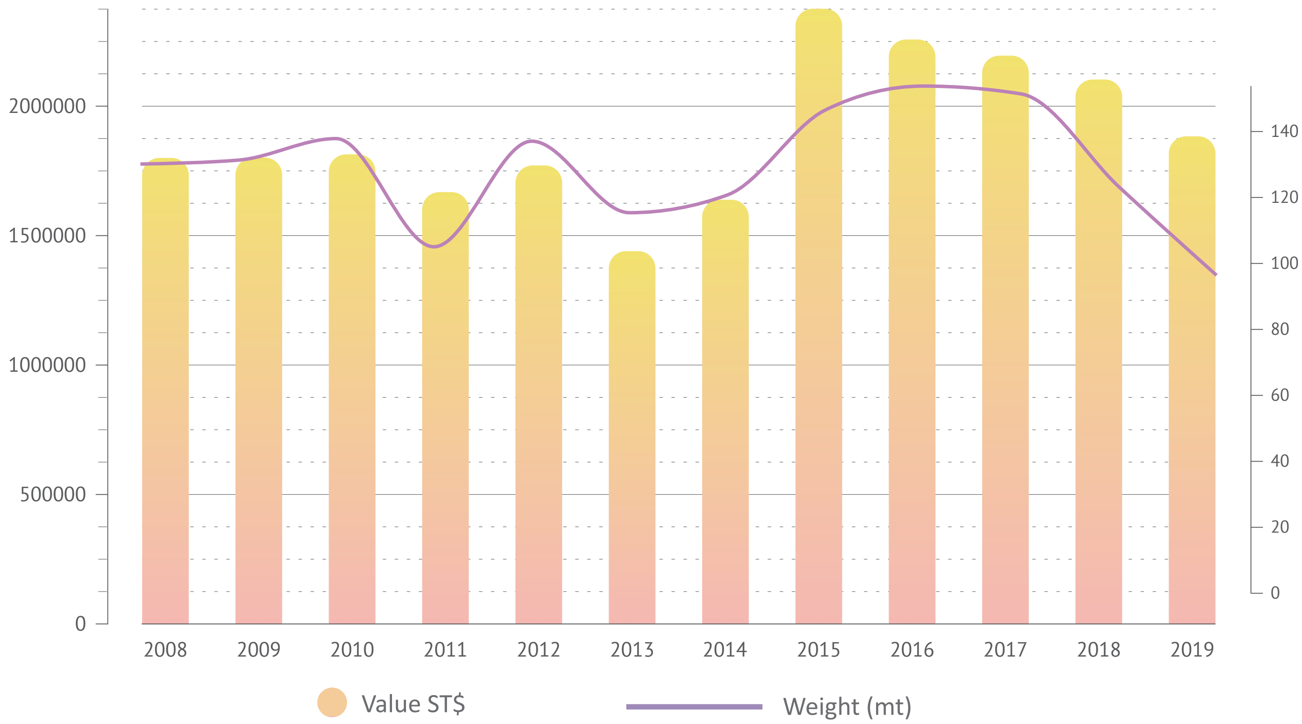
There is however a large difference between the market landings of catch estimated by the Fisheries Division and the estimated catch from inshore fisheries socio-economic surveys as noted by Gillett (2016). For example, the total annual coastal catch of both subsistence and inshore commercial was estimated at 16,870 mt, with finfish catch at 9,066.32 mt/year and 7,804.42 mt/yr of invertebrates in the 2014 socio-economic survey (Tiitii, *et al.* 2014).

Using the HIES (2002) data, the annual coastal commercial catch was estimated at 4,076 mt *value*d at SAT$30 million in 2014 (Gillet, 2016). Gillett suggests that the volume of total catch estimated by both the socio-economic surveys and market surveys appear to be outliers. It seems that the quantity of commercial fisheries given in the annual reports actually refers to the amount of fish monitored, or alternatively, the monitored fish was not adequately extrapolated to reflect all coastal commercial catches in Samoa. The Bureau of Statistics uses the results from the most recent HIES to estimate coastal fisheries production. Fish, invertebrates and traditional processed seafood sold along the Apia-Faleolo roadsides and some stores around the Apia vicinity are monitored once a week only due to budget limitations.

Figure 9 shows that following domestic sales peaking in 2015, quantity and *value* have been declining. Figure 10 shows the broad categories of marine products sold at the local markets in 2019, highlighting finfish as the dominant seafood sold. Polychaete worms are seasonal and available only during October. Sea grapes and green algae are also seasonal. Data on landings is aggregated and not available at the species level. Figure 11 shows the average price per kg of the various categories of seafood. While finfish is the dominant category of seafood, its average price per kg is around SAT$12.50, while polychaete worms (a delicacy) and processed seafood such as sea cucumber viscera generate a much higher price.

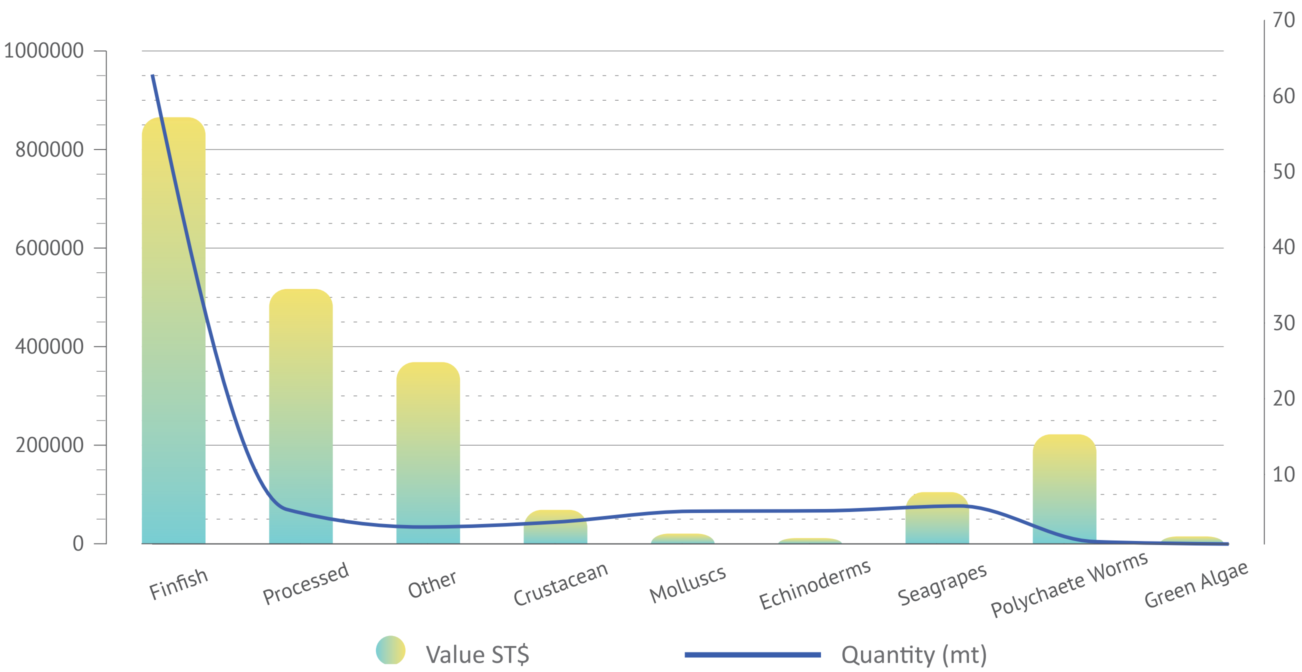
The overall trend in average seafood prices from 2008 to 2019 is presented in Figure 12. It is evident that production in the 3 years from 2017 to 2019 shows a decline, while average overall prices have increased.

Figure 9: Trend in domestic market landings of coastal fish and seafoods



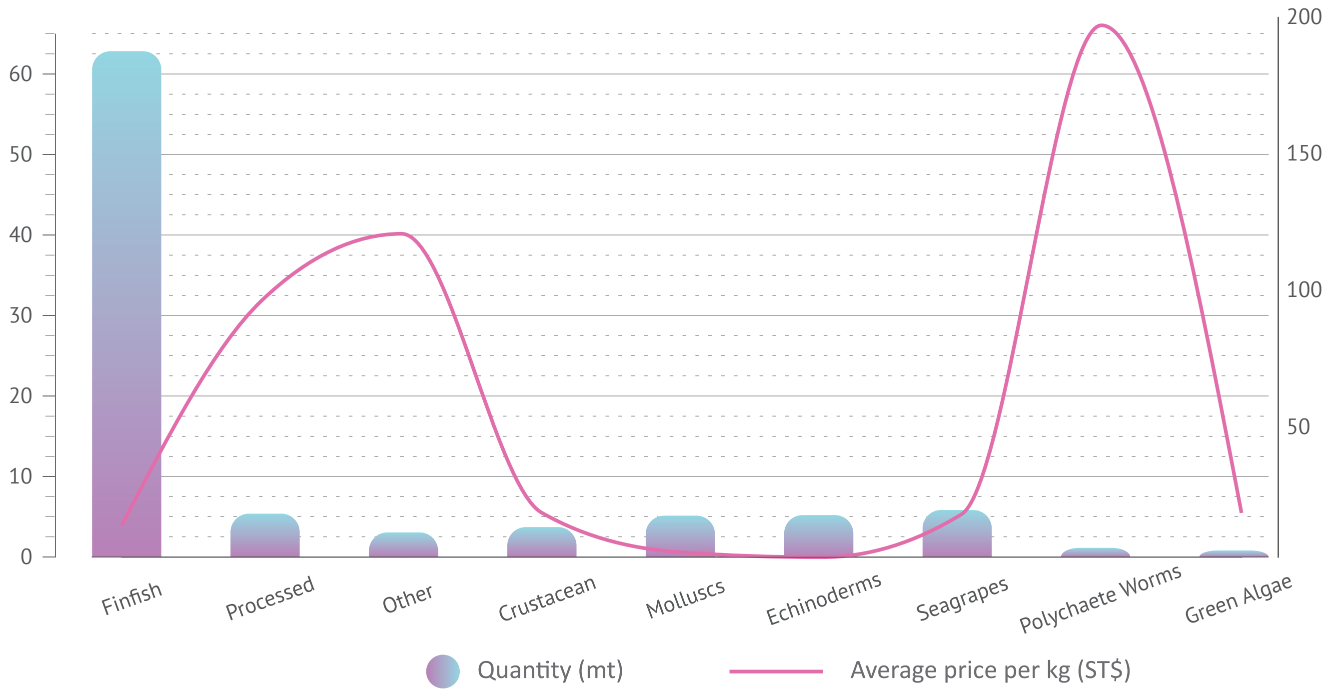
Source: Bureau of Statistics (2016)

Figure 10: Categories of seafood sold at the domestic markets in 2019



Source: Fisheries Division Database

Figure 11: Average price of coastal commercial seafoods in the domestic markets 2019



Source: Fisheries Division Database

Figure 12: Trend in average seafood prices at the domestic markets in Samoa

Source: Fisheries Division Database

To reconcile the anomaly between the socio-economic survey data, HIES data and the Fisheries Division market survey data, this report uses Gillett's (2016) assessment of the coastal commercial catch to compensate for limitations of the Fisheries Division survey coverage which excludes the main market days (Saturdays and Sunday mornings).

Gillett (2014) and (Gillett & Tauati, 2018) suggest the likely estimate of coastal fisheries in Samoa, including subsistence and commercial, to be around 10,000 mt, with half this amount as subsistence and half as commercial; i.e 5,000 mt of coastal commercial fish. Using the HIES (2018) data, the total domestic coastal fisheries was estimated as 10,877 mt (see section 6.1.3) , where half is 5,438. 5 mt as coastal commercial. In light of the declining production trends in the last 3 years shown in Figure 10, the more conservative estimate of 5,000 mt is regarded as more reasonable for coastal commercial catch consisting of lagoon and reef-associated, finfish and invertebrates. However, given the various community-based fisheries management efforts, localised improvements in resources may be occurring, but cannot be confirmed due to insufficient data.

6.2.1.3 Value

Production trends illustrate a reduction of almost 36% in market landings from 2017 to 2019, while prices increased by 26% during this period. Given the low volumes of other seafood commodities and the domination of finfish, the average finfish price of SAT$12.50 is used to estimate the *gross value* of coastal commercial production. Fishing costs include both variable and fixed costs associated with the harvesting, processing and marketing of the fish and other seafood.

Given the diverse nature of the fishery and constraints in deriving reliable cost data, this report uses the *value-added* ratio of 0.8 for coastal commercial fisheries in Samoa noted in Gillett (Gillett, 2014). Therefore, with production estimated between 5,000 and 5,439 mt, and an average market price of $12.50 per kg, total *revenue* would be between SAT$62.5 million and SAT$68 million. Using the equation below to deduct fishing costs by 20% would give the *net value* or *producer surplus* as between SAT$50 million to SAT$54.4 million.

$$\textit{Producer surplus} = \textit{Commercial Fishing Revenue}_{\$}$$

$$- \ \textit{Commercial Fishing costs}_{\$}$$

6.2.1.4 Uncertainty

The above estimate of *producer surplus* has high uncertainty because it is based on certain assumptions. Firstly, that coastal commercial volume of production is equivalent to subsistence production and secondly, that the *value-added* ratio of 0.8 is not based on actual costs incurred by fishers. Another consideration is that production is several times higher than the data from the Fisheries Division market surveys. A further element of uncertainty concerns the composition of the coastal commercial catch, as catch data is only available in an aggregated form. Although the records on catches from coastal and offshore are disaggregated by the Fisheries Division, a large part of the alia catch from offshore fisheries (considered as artisanal fishery) is also sold as finfish in the domestic markets.

Uncertainty arises because it is assumed that 66%[13] of the fish consumed annually in Samoa is pelagic species; it is not clear whether some of these pelagic fish are also recorded as reef related species. Given the variability in the average prices of fish and seafood in Samoa, the average market price of SAT$12.50 per kg of finfish also seems more on the conservative side. In view of the trend of increasing prices, it is likely that the *producer surplus* could be higher.

6.2.1.5 Sustainability

The sustainability of coastal fisheries depends on the area and quality of critical coastal habitats relative to the level of exploitation. The trend data from the Fisheries Division shows a decline in production. Many coastal fish and invertebrates are associated with specific habitat types such as coral reefs, lagoon, mangroves and seagrass areas. Therefore, any impact on these will have a direct effect on their fisheries. Some reefs have been affected by pollution and sedimentation, as well as crown-of-thorns, cyclones and coral bleaching linked to an increase in temperature (Kwan, *et al.*, 2016; Ziegler, *et al.*, 2018 and Nise, 2005). It is also worth noting that 95% of Samoa's reefs are at risk (Paeniu, *et al.*, 2015).

In the face of the global pandemic, the downturn in the tourism sector, and limited emigration, likely places additional pressure on the coastal resources to support people's livelihoods in the interim. The sustainability of the fishery must be based on scientific measurement of fisheries, such as maintaining biomass, stock trends, CPUE trends, the age/size structure of populations and their reproductive capacity.

13 32 kg of the 48.5 kg per person of fish consumed annually in Samoa is pelagic (Tolvanen, Thomas, Lewis, & McCoy, 2019, p. 17)

A variety of management initiatives has been established under the community-based fisheries management programmes in coastal communities. Strong traditional village rules and customs have empowered these communities to lead the management of their coastal resources. However, community leaders must maintain these existing restrictions and management measures to ensure long-term sustainability of the resources.

6.2.1.6 Distribution

Samoan households, and particularly fishing families, receive most of the benefits from coastal commercial fisheries. A high portion of household seafood consumption is from reef fishes, invertebrate and nearshore pelagic resources, and since the harvest is predominantly conducted by local communities, any income generated from their sales is directly received by the local people.

6.2.1.7 Sea Cucumber

Sea cucumbers (also known as beće-de-mer in processed form) are marine invertebrates found throughout the Tropical Indo-Pacific region including Samoa and are harvested for subsistence consumption and for the lucrative South-east Asian markets. Sea cucumber fishery records are available from the early 1990s, although this fishery started in Samoa much earlier. By mid-1993, five companies were harvesting, processing and exporting sea cucumbers to China (ESCAP, 2003). Given the sedentary nature of sea cucumbers and the simple artisanal fishing methods used, the higher *value* species declined, and by 1994 export was banned from Samoa to allow stocks to recover (Sapatu & Pakoa, 2013; Compliance Unit, 2014). Some species such as dragonfish (*Stichopus horrens*), curryfish (*S. herrmann*) and brown sandfish (*Bohadschia marmorata)* continue to be harvested for subsistence and domestic markets (Sapatu & Pakoa, 2013).

6.2.1.7.1 Identify

A resource assessment survey to determine the commercial viability of the fishery was conducted in 2006 (Eriksson, 2006). This assessment showed that stocks of seven species of sea cucumbers were still limited in range and density, despite the export fishery having been closed for over 10 years. The study recommended keeping the fishery closed from commercial exploitation, even though some species showed viable stocks for short-term commercial exploitation. Sea cucumber is consumed and marketed locally as a mixture of intestine (viscera) and body wall, mixed with seawater and other invertebrate products and seaweeds. Annual landings are assessed by bottled units and converted to tonnes.

Sea cucumbers are sought after by both men and women artisanal and subsistence fishers. Women mostly harvest on reef flats at low tide, while men target reef-top areas or dive for them during the day or at night. The current level of fishing effort is unknown given the informal nature of the fishery.

6.2.1.7.2 Quantify

Total production of bottled sea cucumber at the local markets, including roadside and municipal markets, increased from 2000 and peaked in 2003 at over 8,000 bottles[14] (4298 kg), gradually declining to 3,164 bottles (1,637 kg) in 2012 (Sapatu & Pakoa, 2013). Figure 13 on the next page shows the sale of pickled sea cucumber in Samoa from 2000 to 2012.

The bottles, which are often used as food gifts, are readily available from the roadside stalls around the country. More recent data on the quantity of sea cucumber and the *value* of the different species have not been available, as it is aggregated with either 'processed seafoods' or in the case of consumption, in its raw form under 'echinoderms'.

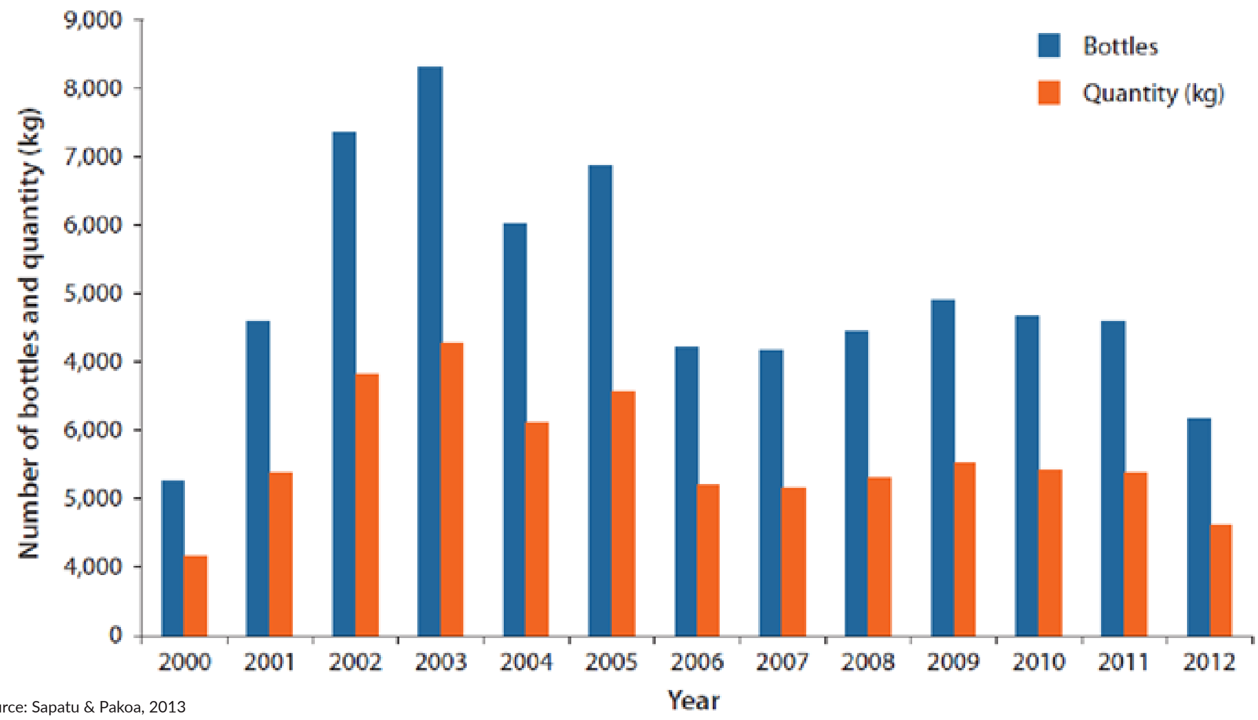
6.2.1.7.3 Value

Of the five species of sea cucumber consumed in Samoa, three species i.e. brown sandfish, dragonfish and lollyfish, comprise 90% of the landings (Eriksson, 2006). The *value* of sea cucumber sold is increased if it is mixed with sea grapes (*Caulerpa racemosa*) or sea hare eggs (*Dolabella auricularia*), and a small amount of dragonfish viscera. Bottled dragonfish (*sea*) is the most sought-after product, with a price ranging from SAT$25 -SAT$50 for a 750 ml bottle and SAT$10-SAT$15 for a 285 ml bottle (Sapatu & Pakoa, 2013). The local sea cucumber industry has contributed on average over SAT$126,000 annually to the local Samoan economy over the last 13 years (Sapatu & Pakoa, 2013).

Given the gaps in data on the recent sea cucumber fishery in Samoa, one can assume that annual production would be similar to the 2013 estimate of SAT$126,000 annual production over 13 years. Therefore, a conservative estimate of annual production is likely to be around 1,600 kg. Considering the simple fishing techniques involved,

14 Conversion of the number of bottles to quantity is based on the average weight of bottles that are mostly marketed: large bottles (750 ml); small bottles (285 ml)

Figure 13: Sale of picked sea cucumbers in Samoa (2000 – 2012)



Source: Sapatu & Pakoa, 2013

the *value-added* ratio of 0.9 applied by Gillett (2016) for coastal subsistence fishery for Samoa is used to determine fishing costs. A conversion to 2019 prices estimates the net benefits from the fishery to be about SAT$139,165.20.[15]

6.2.1.7.4 Uncertainty

Recent available data on sea cucumber fishery has been aggregated, which does not allow for differentiating production levels based on species and types of fishing effort. Additionally, illegal harvesting of sea cucumbers has occurred. For example, a shipment of some 40-60 bags was intercepted at the airport by Fisheries Enforcement personnel in 2010 (Sapatu & Pakoa, 2013). Another consignment was intercepted in 2013, and in 2014, 'Greenfish Operation' was established to investigate the illegal processing and export of sea cucumbers. It is difficult to determine the extent of illegal trade considering the increasing demand for *Bêche-de-mer* and the likelihood of concealment as part of passenger luggage. A more accurate assessment of catch data could improve understanding of the trends in the fishery for the different species.

6.2.1.7.5 Sustainability

The moratorium on commercial harvesting of sea cucumbers has allowed stocks of lollyfish and greenfish to grow to their maximum size ranges (Sapatu & Pakoa, 2013). The report further indicated that species exploited by subsistence fishery (brown sandfish and dragonfish) were not in a healthy stock status and required management intervention (Fisheries Division, 2015). To avoid overharvesting and depletion of stocks, the Samoan Fisheries Division developed a National Sea Cucumber Management and Development Plan (2015). The plan outlines various management measures, such as restrictions on areas and fishing periods, gear limitations, licenses & permits, export prohibitions and other initiatives. The plan's objective is to manage and develop a sustainable fishery while maintaining the sea cucumber's cultural and traditional importance.

15 Average annual inflation from 2013 to mid-2019 of 1.25%. Statista.com/statistics/728311/inflation-rate-in-Samoa.

The Blue Pacific Company Ltd was granted a sea cucumber aquaculture license in 2015. A hatchery facility was established at Apolima Island under the supervision of the Fisheries Division. Ongoing experimental trials may be necessary to succeed in re-stocking over-exploited areas to avoid the boom and bust harvesting cycles.

6.2.1.7.6 Distribution

The benefits from the sea cucumber fishery accrues directly to men and women in Samoan fisher families and the wider community who consume sea cucumber products. Benefits arise from the availability of either the raw product or its processed form in local markets or roadside markets.

6.2.1.8 Deepwater bottom fishing

This fishery operates along the deep reef slopes and nearshore shallow seamounts and banks at depths ranging between 100 – 400m. While this depth range is shallower than for the long-lived deep-sea species (400 – 2000m), it is deeper than the adjacent shallow water coral reef and lagoon fisheries (0-50m) (Gomez, *et al*., 2015). The deep-water bottom fishery is seen as an alternative to fishing on, or in, shallow reefs. With technical assistance from SPC, successful fishing trials, and installation of hand reels on alia vessels,[16] the deepwater bottom fishery expanded to target snappers, emperors and groupers. The alia fleet fished along the Southern Shelf area and reef slopes, landing high-*value* fish for air freight to Hawaii. Fishing for deepwater snappers continued through the 1980s with catches averaging around 400 mt per year. In 1986, the fishery peaked to 950 mt and catches began to decline (Vunisea, *et al*., 2008).

Although Samoa was one of the first Pacific Island Countries to deploy deep-bottom fishing technology, the newer alia vessels are multi-purpose which allows them to alternate between trolling and longlining depending on weather and market demand. About five to ten alia still practise bottom fishing where fishers are more likely to target emperors present in shallow depths rather than deep-water *Etelis* or *Pristipomoides* (International Business Publications, 2017). The majority of catch is marketed locally.

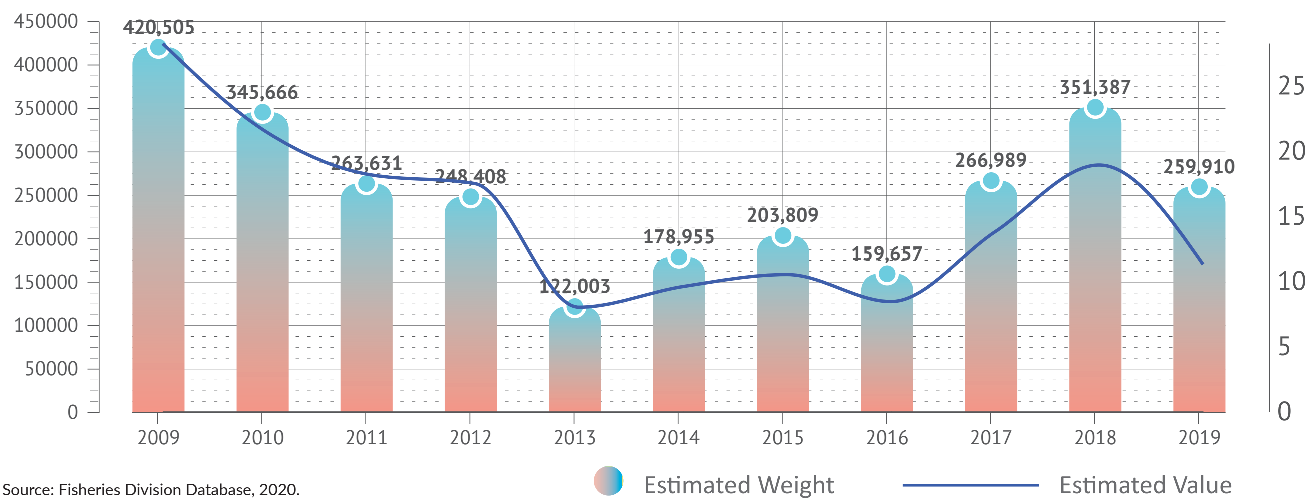
6.2.1.8.1 Quantify

In 1990, an assessment of deep-water snapper resources indicated a MSY of 88 mt, which could be caught by 14 alia vessels (Chapman, 2014). Two cyclones in 1990/91 devastated the alia fleet, and by 1993-1994 the catches were below sustainable levels (Bell & Mulipola, 1995). The alia fleet targeting bottom fish gradually reduced and effort shifted towards trolling and longlining.

The bottom fishery in Samoa can be characterised by a boom and bust cycle. Figure 14 shows that in 2009, the catch had increased to 28.25 mt, but by 2013 had fallen to 8.02 mt. It increased again in 2018 to 18.93 mt and fell in 2019 to 11.3 mt. The annual average catch is estimated as 13.8 mt, based on Fisheries Division data over the last 10 years.

16 Alia is a catamaran style-vessel around 9 metres in length, originally constructed from plywood but currently constructed from aluminium, powered by an outboard motorised engine. The vessel was originally designed in the 1970s with up to four hand reels and trolling booms for bottom fishing to depths up to 400m for deepwater snappers and trolling offshore for tuna and other pelagic species.

Figure 14: Estimated *value* and quantity of deep bottom fish in Samoa from 2009 to 2019



Source: Fisheries Division Database, 2020.

6.2.1.8.2 Value

Other reasons for the reduction in interest in bottom fishery include poor air freight links to the Hawaiian market, securing reliable supplies, and the absence of premium prices paid in the local markets (McCoy, M A, 2010). Given that fishers with larger vessels have opted for tuna trolling and long-lining, only a small number of vessels are still engaged in deep-water bottom fishery. Post-harvest issues relating to storage and maintaining quality continue to be a constraint on small alia vessels.

Specific details on the estimated costs for this fishery do not exist. Samoa's *value-added* cost ratio of 0.8 for coastal commercial fisheries (Gillett 2016), and the gross *market value* of the catch generated the following estimates for 2018 (SAT$351,387), and 2019 (SAT$259,910). The *net value* of the fishery can be estimated as SAT$281,109.60 in 2018 and SAT$ 207,928 in 2019,while the annual net average *value* for the last 10 years is SAT$192,034.

6.2.1.8.3 Uncertainty

Much uncertainty exists about fishing costs, the number of licenses and fishers currently targeting bottom fishes in Samoa. Commercial fishers using alia catamaran vessels would only be drawn to deep-bottom fishery if bottom fishery prices were competitive with tuna, and catches attracted premium local market prices. Consequently, alia vessels of less than 11 metres alternate between tuna trolling, longlining and bottom fishing for snappers (Tolvanen,*et al.*, 2019). Export markets continue to face air freight problems, further complicated by seasonal demand and price sensitivity to quality (McCoy, 2010).

6.2.1.8.4 Sustainability

Deepwater bottom fishes, which are generally slow-growing, long-lived species that aggregate to spawn, must be relatively old and large before they can reproduce. Natural reproductive rates and mortality rates are low, thus making them easily prone to overfishing.

Using existing spatial data Gomez (Gomez, *et al.*, 2015) developed a regional species distribution model to determine the potential distributional range of deep-sea snappers in the Pacific Islands. The potential area[17] and proportion of suitable habitat of deep-sea snappers in Samoan waters were given as:

Samoa	*Etelis*		*Pristipomoides*		*Aphareus*		Estimated unexplored biomass (t)
	Area	Proportion	Area	Proportion	Area	Proportion	
	22.3	0.16	37	0.27	41.6	0.3	190

Potential area (x 10^3 km^2)

Extracted from (Gomez, *et al.*,2015)

Figure 14 shows recent production levels of less than 20 mt in 2018/2019. Thus the estimation of sustainable yield of 19-57 mt per year (Secretariat of the Pacific Community, 2013) or approximately half the unexploited biomass level of 95t, does not seem to pose a direct threat to the fishery (especially in light of the proportion of potential habitat existence area and the current exploitation rates). However, management of fishing pressure, with both effort and catch controls, will be necessary to maintain a sustainable fishery. A management plan that includes provision of collecting species specific data, fishing effort and environmental details would be essential to avoid the boom and bust nature of this fishery.

6.2.1.8.5 Distribution

The benefits from deep-water bottom fishery accrues to Samoan fishers and consumers. The alia vessels are locally owned by Samoans, and consumers are local people and tourists visiting Samoa who benefit from the availability of fish in local markets and restaurants. A small quantity is also exported as mixed finfish in passenger luggage to friends and relatives of Samoans living abroad.

17 The potential area (X 103 km2) was calculated using the total area of 0.25° cells within which suitable habitat was identified, and therefore provides an upper bound for true habitat area. Estimates of unexploited biomass for the EEZ are from (Dalzell & Preston 1992).

6.2.2 Offshore fisheries

The offshore fishery is characterised by fishing activities in the deeper waters and open oceanic environments beyond the outer-reef slope areas, often with more modern gear and technology. The offshore fishery in Samoa broadly consists of bottom fishing for snappers[18], trolling for skipjack and other pelagic species, and longlining for tuna. Therefore, the two main types of fishing gear used to target tuna and tuna-like species are troll and longline, which will be discussed under this section, while bottom fishing is discussed in the above section (6.2.1.6.2).

The tuna longline fishery was the backbone of Samoa's economy and the main foreign exchange earner in its early years of development (Government of Samoa, 2017). The current domestic longline fleet ranges from around 12.5 m to over 20.5 m in length. The commercial fishing fleet for tuna comprises domestic fishing vessels and foreign fishing vessels licensed to fish in Samoa's EEZ. Catches from the commercial longline fleet are landed and processed in Samoa before export.

Gillett (2009; 2014) noted the difficulty in separating the catch of small alia catamarans from the larger catamaran and monohull vessels, thus categorising all catch from alia vessels as 'offshore locally-based' catch as opposed to 'offshore foreign-based'. Using the definition of coastal fisheries in Samoa's Coastal Fisheries Management and Development Plan (Secretariat of the Pacific Community, 2013) and to avoid double counting, this report discusses the catches of all tuna and tuna-like species under the offshore fisheries category, while bottom fishing is discussed under the coastal commercial section.

6.2.2.1 Identify

Although tuna fisheries in Samoa are relatively smaller than most other Pacific Island Countries because of the relatively small size of Samoa's EEZ, tuna generates an important source of income for the government and remains the dominant fish export. The industry provides employment on fishing vessels, at port and in processing establishments. Government *revenues* are generated from access fees through licensing. Since the mid-1990s, catch rates of albacore tuna in Samoa's longline fishery have been amongst the highest in the region, with large annual catches (>4,000 mt) in some years, constituting up to 12% of the total annual South Pacific catch (Fisheries Division, 2017). Tuna catches from the longline fishery account for about 0.3% of the total catches of tuna in the Western and Central Pacific Ocean region.

The fishery operates all year round, targeting large or mature South Pacific albacore tuna, which accounts for about 75% of the total landings and is exported frozen to canneries in American Samoa. Yellowfin represents about 12% of the total landings, and together with bigeye, is an important component of fresh chilled fish exports[19]. Non-targeted, or bycatch, caught accidentally while fishing for tuna, is relatively low in Samoa. For example, in 2018, by-catch represented 2.4% of the total longline catch, while in 2017, it was 3%. Main bycatch species include dolphinfish, wahoo and barracuda, which are all sold in local markets or to restaurants. Overall, albacore is the mainstay of the longline fishery and its availability dictates its operation.

Table 8 shows the number of Samoan vessels active in Samoan EEZ from 2013 to 2018, by gear and size. The

Table 8: Number of Samoan vessels by gear and size in Samoa's EEZ 2013 – 2018

Class	Length (m)	Fishing method	2013	2014	2015	2016	2017	2018
A	Up to 11	Mixed*	27	29	42	57	49	42
B	> 11 – 12.5	Longline	0	0	0	0	0	
C	> 12.5 -15	Longline	2	2	1	1	1	1
D	>15 – 20.5	Longline	8	7	6	6	7	4
E	> 20.5	Longline	2	4	4	4	4	4

* shift gear from longline, troll and bottom fishing

Source: (Fisheries Division, 2019)

18 Bottom fishing is discussed in detail under domestic commercial fishery.

19 Total landings include skipjack catches from purse seine and troll fishery.

bigger vessels (greater than 12.5 in length) were all engaged in commercial longlining for albacore. Using the artisanal longline fishery data from the Fisheries Division, the average annual catch was about 23.8 mt for the last 7 years, with an annual *value* of SAT$344,541.

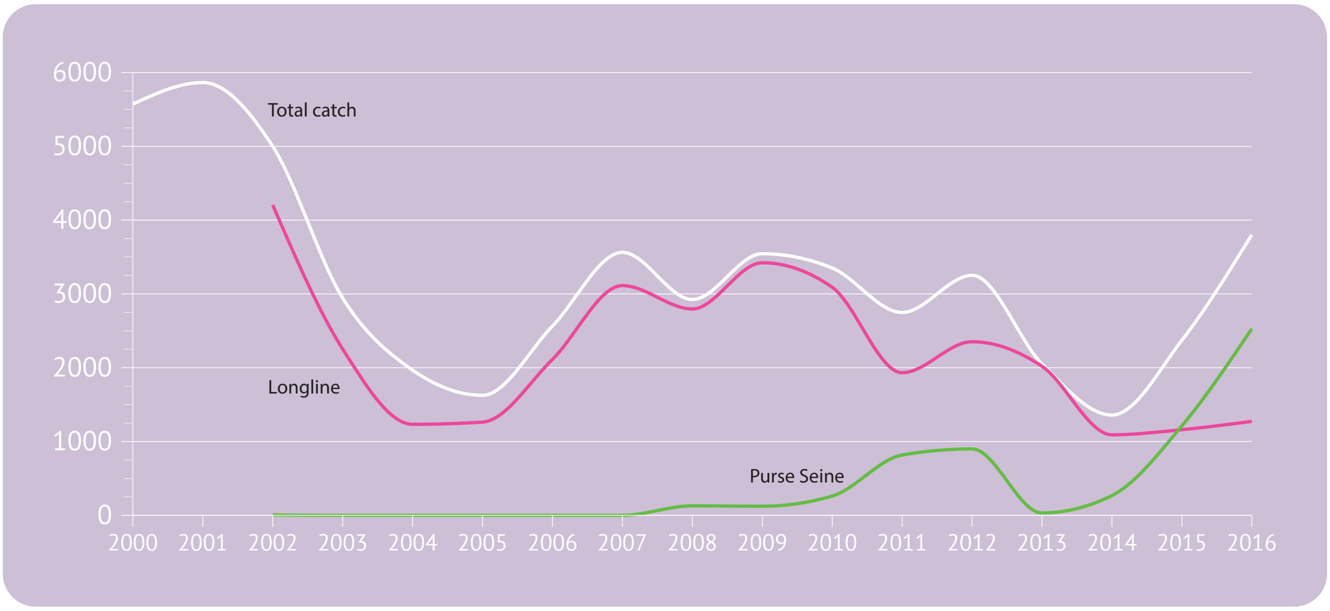
Foreign fishing in Samoa commenced in 2015 with 10 vessels in Samoa's EEZ under an access agreement linked to the establishment of an onshore fish processing facility. In 2018, 16 foreign fishing vessels operated out of Apia i.e. six vessels flagged to the Cook Islands and ten flagged to Vanuatu (Fisheries Division, 2019). Consequently, exports increased as a result of foreign fishing re-exports out of Samoa.

The only foreign purse seine fishing in Samoa is by US vessels, under the US Multilateral Treaty. These vessels, which do not land their catch or tranship in Samoa, are restricted to a limit of 150 days in the country's EEZ. Since 2015, foreign purse seine vessels owned by Huanan Fisheries (Samoa) fishing in Parties to the Nauru Agreement (PNA) waters, tranship in Samoa from where all the catches are exported.

6.2.2.2 Quantify

Data on tuna catch is more robust than for any other fishing sector in the South Pacific. Catches are measured and verified using log sheets, and observer data is verified by boat captains' estimates and port sampling using actual measurements at the port. The trend in production by major gear type in Samoan waters is shown in Figure 15 using the Forum Fisheries Agency Database which is standardized data and verified by the SPC.

Figure 15: Tuna catch in Samoa's Exclusive Economic Zone 2002 – 2016 (Metric Tonnes)



Source: FFA Database 2020

The above graph shows that catches have been variable over the 15-year period but dominated by longline. The purse seine catches are by vessels fishing under the US Multilateral Treaty. Although these catches occur in Samoa's EEZ, they are not part of national fish landings.

Annual catch estimates of tuna and tuna-like species as bycatch caught by the domestic longline fleet, are presented in Table 9 for 2013 to 2018. Albacore is the major species followed by yellowfin, then bigeye tuna. The average annual total catch from Samoan waters over the 15-year period was 2,871 mt of tuna, with an average annual longline albacore catch of 2,221 mt.

Table 9: Annual catch Estimates (mt) of domestic longline fleet by primary species in Samoa 2013- 2018

Species	2013	2014	2015	2016	2017	2018
Albacore	1,642	808	840	946	2,227	1,684
Bigeye	36	48	48	61	140	60
Black marlin	5	8	7	4	5	3
Blue marlin	7	8	7	6	80	33
Oceanic white tip	0	0	0	0	0	0
Skipjack	14	15	20	20	59	44
Silky shark	0	0.08	0.08	0	0	0
Striped marlin	5	4	4	3	1	2
Swordfish	3	4	5	3	14	12
Yellowfin	330	231	252	239	584	401
TOTAL	2,042	1,126	1,183	1,282	3,110	2,241

Source: (Fisheries Division, 2019)

The volume of exports of tuna and tuna-like species from Samoa is given below in metric tonnes for 2010 to 2018.

2010	2011	2012	2013	2014	2015	2016	2017	2018
2,702	1,329	1,820	1,441	732	2,226	4,345	4,104	4,165

Source: (Fisheries Division, 2019; 2015)

The difference in the quantity caught by domestic vessels and the quantity exported in 2013 and 2014 is assumed to be the amount that was consumed domestically, and/or exported as part of passenger luggage to friends and families of Samoans.

Tuna exports averaged 2,318 mt annually from 2010 to 2018 and largely consisted of frozen albacore and yellowfin, although since 2016 exports have increased to around 4,000 mt accompanied by an increase in foreign fishing vessels. The total annual fee from local fishing vessels ranges from SAT$200 for vessels less than 11 m in length to SAT$10,000 for vessels 20.5 m and over. *Revenue* is also derived from foreign fishing vessels through the payment of an annual access fee of US$15,000.

Employment is an important component of the tuna industry throughout the Pacific Islands and provides an indirect resource derived benefit. A 2017 study by Terawasi and Reid estimated that 387 people were employed in the tuna industry through harvesting, processing, observers and as government employees (Terawasi & Reid, 2017).

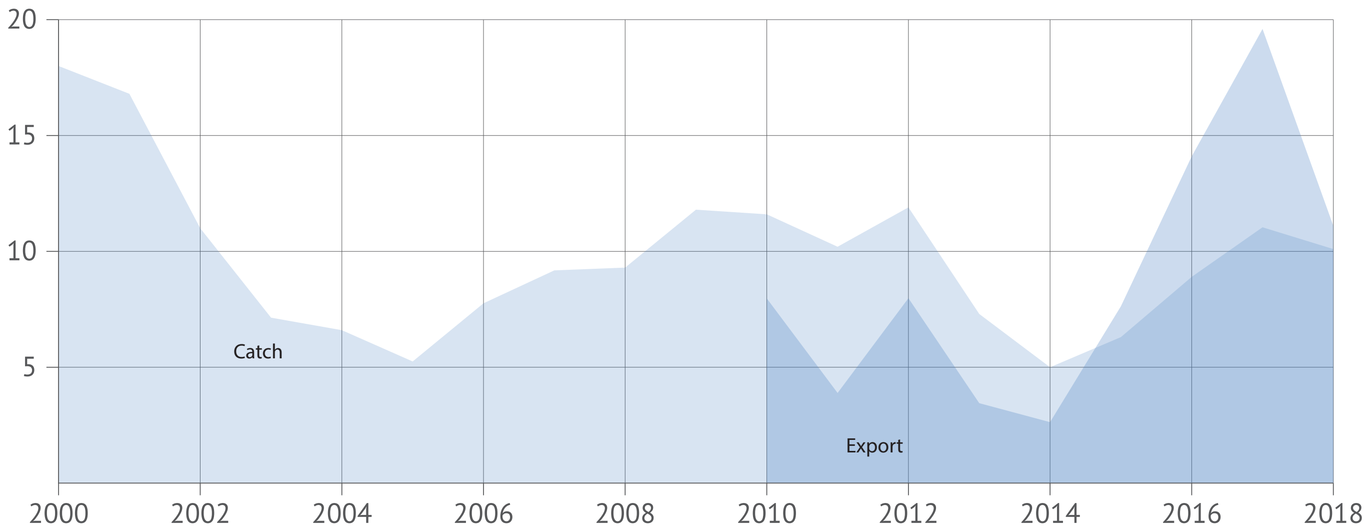
6.2.2.3 Value

An accurate reflection of trends in the prices operators receive for the various species they catch due to price fluctuations cannot be provided by a single figure. Price depends on the market destination, demand, and cost of transportation. The Forum Fisheries Agency calculates the *gross value* of tuna using global tuna prices as an indicator i.e. Thai import prices for frozen albacore; the Yaizu market price for yellowfin caught by longline and prices at Japanese ports for bigeye (Terawasi & Reid, 2017). Prices are specific to each year, adjusted for *inflation* through the FAO Fish Price Index, and converted to 2018 US dollars. The average catch of tuna from 2000 to 2018 was 3,304 mt, with an estimated *value* of US$9.75 million, while average annual exports were 2,318 mt, with an estimated *value* of US$8.71 million over this period. This includes fish caught by foreign vessels and landed in port in Samoa.

The estimated average annual *value* of exports from 2010 to 2016 prior to the entry of foreign fishing vessels was US$6.81 million, while the average annual catch was 2,705 mt with an estimated *value* of US$8.74 million for the same period. Figure 16 shows the total catch and *value* of exports of tuna from Samoa.[20] Total tuna catches in 2014 and 2015 were 1,358 mt and 2,372 mt while in 2017 and 2018, catches increased to 4,104 and 4,165 respectively. For the same period, the *value* of exports in 2014 and 2015 was US$5 million and US$6.3 million while the *value* of exports of tuna increased to US$11.04 million in 2017 and US$ 10.1 million in 2018.

20 Exports here are valued using albacore (75%), yellowfin (20%), bigeye (4%) and other (1%).

Figure 16: Total catch and estimated export *value* of tuna for Samoa



Source: Data extracted from (Terawasi & Reid, 2017); FFA Database, (Fisheries Division, 2019)

Longline fishing operational costs are determined by several factors including fuel, wages, provisions, and bait. Fuel is a major operational cost subject to large fluctuations, thus an important determinant in the change in fishing costs over time.[21] The net economic benefit to fishers of this offshore oceanic ecosystem service can be estimated by subtracting fishing costs from the gross value of the tuna catch. This gives the value-added estimate of the fishery. Given the variability in fishing operations due to the different sizes of fleets, data on annual fishing days for local and foreign fishing vessels were not available to calculate the total fishing costs. Studies by Gillett and Terawasi and Reid were therefore used to determine the likely fishing costs for the Samoan longline fishery (Gillett, 2016) and (Terawasi & Reid, 2017).

Using the economic study of the longline industry in Samoa (Hamilton, 2007), Gillett used 0.4 as the *value-added* ratio for the Alia longline fleet in Samoa to calculate the *value-added* benefits from the tuna fishery. With an annual estimated catch *value* of US$9.7 million, the net benefit would be US$3.88 million annually. A more recent study by FFA used a fishing cost index to derive the *value-added* ratio and estimated the average *value-added revenue* per tonne for Samoa as US$1,096.84 between 2013 and 2016 (Terawasi & Reid, 2017). Applying this ratio to the average total catch of 2,705mt from 2010 to 2016, gives an annual *value-added revenue* of US$2,966,952. The *value-added* for average annual longline catch gives an annual net benefits range of US$2.97 million to US$3.88 million (2018 prices).

The government of Samoa receives benefits from license and access fee from vessels that fish in Samoan waters. Using the number of vessels registered from Table 8, the average annual license fee for different vessels from 2014 to 2018 is estimated to be SAT$103,360 or US$37,726. In 2018, 16 foreign fishing vessels each paid an annual fee of US$15,000, with a total apparent fee of US$240,000. In addition, the US South Pacific Tuna Treaty is an ongoing agreement between the USA and 16 Pacific Island

21 Terawasi and Reid used Information on fuel cost relative to total production cost to derive the fishing cost index for the Southern Albacore longline fishery to calculate the likely cost trends in the fishery for the FFA member countries and the region (Terawasi & Reid, 2017).

Countries, including Samoa, which allows US purse seine vessels to fish in the EEZ of the Parties to the Treaty. The revised Treaty in 2016 defines the number of fishing days in waters of the Parties to the Treaty exclusively available to fishing vessels from the US, as well as defining a mechanism for US vessels to arrange for additional fishing access through engagement with the countries involved.

Fishing in the Samoan EEZ is under an agreed rate for each day fished and an annual limit of 150 purse seine fishing days applies. For the fiscal year 2016-2017, the US fleet caught 2,045 mt of tuna in Samoan waters, of which 84% (1,270 mt) was skipjack, 272 mt yellowfin and 48 mt bigeye (Ministry of Agriculture and Fisheries, 2018). Using world market prices for tuna (Terawasi & Reid, 2017) and adjusting with the FAO fish price index, the estimated value of this catch is about US$2.54 million.

Although the total annual access fee under the Treaty paid to Samoa based on catch is unavailable, the economic development fund[22] for the fiscal year 2019/20 was SAT$1,333,264 or about US$501,841 (Government of Samoa, 2020). The FFA estimated that the license and access fee revenue for Samoa from tuna was US$1 million in 2016. Based on Table 7, the average annual license and access fee can be estimated to be around US$755,556. However, this is likely to be a conservative estimate as there has been an increase in US purse seine fishing in Samoan waters since 2017.

Table 10 summarizes the annual benefits for Samoa from the tuna fishery in 2019 US dollars. Table 11 shows that the average annual employment earnings from 2013 to 2016 was estimated to be US$1.1 million, while annual average local purchases was estimated to be US$1.05 million.

22 Economic development fund is the development assistance fund as part of the US Multilateral Treaty paid to all FFA members irrespective of whether tuna is caught within their EEZ or not.

Table 10: Summary of average annual tuna *value* estimates in US Dollars (2019 prices)

	Gross value of catch* (US$ m)	*Net value* (US$ m)	*Gross value* of exports (US$ m)	Government *revenue* (US$ m)	Employment earnings (US$ m)	Local purchases (US$ m)
Min	8.76	2.96	6.82	1.18	1.98	1.24
Max	9.77	3.89	8.73			

* Variability primarily due to inclusion of foreign fishing access; Price adjusted to 2019.

Table 11: Samoa tuna catch, values and economic contribution

	Units	2008	2009	2010	2011	2012	2013	2014	2015	2016
National waters catch	tonnes	2,924	3,545	3,351	2,749	3,251	2,052	1,358	2,372	3,801
Longline		2,796	3,422	3,090	1,932	2,352	2,020	1,091	1,160	1,273
Purse seine		128	123	261	817	899	32	268	1212	2,528
Value of catch	US$(m)	9.3	11.8	11.6	10.2	11.9	7.3	5.0	6.3	8.9
Longline		9.1	11.6	11.2	8.8	10.0	7.2	4.6	4.8	5.3
Purse Seine		0.22	0.15	0.36	1.4	1.9	0.07	0.40	1.5	3.7
National fleet										
No of Longline vessels	number	44	42	50	46	36	39	42	53	68
Catch longline	tonnes	2,796	3,422	3,090	1,932	2,353	2,022	1,102	1,160	1,273
Value of longline catch	US$(m)	9	12	11	9	10	7	5	5	5
Economic contribution										
Contribution to GDP	US$(m)									
Harvest sector only		3.0	3.8	3.7	2.9	3.3	2.4	1.5	1.6	1.8
Combined harvest & onshore processing		na	na	na	na	na	1.8	1.1	2.1	2.7
Licence & access fee *revenue*	US$(m)	0.6	0.7	0.7	0.6	0.5	0.8	0.9	1.0	1.0
Onshore processing volumes	tonnes	na	2,259	4,261	1,873	2,725	2,209	1,344	1,329	2,300
Employment	number	387	293	414	395	415	325	327	327	387
Exports	US$(m)									
Japan		0.014	0.003	0.021	0.014	0.023	0.005	0	0.76	0.59
USA		0.50	0.65	0.34	0.34	0.18	0.012	0	0.52	0.73
Balance of payments	US$(m)	na	na	na	na	na	2.4	1.4	4.9	5.5
Employment earnings	US$(m)	na	na	na	na	na	0.7	0.4	1.6	1.7
Local purchases	US$(m)	na	na	na	na	na	0.5	0.3	1.7	1.7

na – not available

Source: (Terawasi & Reid, 2017: 41)

6.2.2.4 Uncertainty

The main sources of tuna fisheries data on catch and effort are provided by log sheets checked by observers and port sampling which are further verified by Vessel Monitoring System (VMS) data. In 2018, 95% of domestic longline vessels submitted log sheets, and 15.6% of the landings had port sampling coverage (Fisheries Division, 2019). However, data reported by the Samoan Fisheries Department differs to that recorded by the Secretariat of the Pacific Community. Data from SPC is standardised to a regional model because tuna is a highly migratory species, therefore SPC data are more frequently cited, although the Samoa catch data may be more accurate because it is the primary source.

Table 12 shows the collection of statistics that quantify the magnitude and *value* of the commercial tuna fishery. The list represents information currently available about the Samoan tuna resource. The data derived from various sources and *values* are based on a range of estimation methods. A high degree of uncertainty about the *real economic value* exists due to the range of methods used. In particular, estimates of fishing costs were derived from *value-added* ratios, rather than actual variable fishing costs. Fish exports are also based on import prices in Thailand and Japan as an indicator of world tuna prices, while most exports are frozen albacore destined for the American Samoa canneries.

Table 12: Samoa tuna catch data summary

	Data	Author/Source	Comments
Tuna harvest	2,705 mt	FFA database; (Terawasi & Reid, 2017)	Average 2010–2016
	2,871 mt	FFA database	Average 2002–2016
	3,304 mt	FFA database; (Terawasi & Reid, 2017); (Fisheries Division, 2019)	Average 2000–2018
Gross value of tuna	US$8.76–US$9.77 million	All above	
Value added	US$3.5–US$3.9 million	All above	0.4 VAR for Samoan Longline alia vessels
	US$2.9--US$3.62 million	All above	$1,096.84 per tonne for harvesting & onshore processing
Exports	US$6.81–US$8.71 million	All above	Average 2010–2016 Average 2010–2018
Government *Revenue*	US$1.8 million	(Terawasi & Reid, 2017)	Local & foreign license
Fishing Costs	US$5.25–US$5.85 million	(Gillet, 2016)	1-VAR = 0.6
	Vessel operating cost		Not available
No of vessels and fishing effort	52		Average (2013–2018)
	No of vessel days		Not available
Employment	387	(Terawasi & Reid, 2017)	2016
Employment earnings	US$1.98 million	(Terawasi & Reid, 2017)	2019
Local purchases	US$1.24 million	(Terawasi & Reid, 2017)	2019

6.2.2.5 Sustainability

The variability in oceanography and climate over time influence the annual availability of albacore. The seasonality often results in peaks and troughs in catch and the number of fishing vessels operating within a year and between years (Fisheries Division, 2017). Samoa's tuna fisheries are based on stocks that range widely throughout the Western and Central Pacific Ocean. As a signatory to the FFA and WCPFC Convention, Samoa is obliged to cooperate with other Pacific Island Countries fishing in the WCP Ocean to effectively manage tuna stocks. The country is also a member of the Te Vaka Moana and Tokelau Arrangements that provide a framework for the sustainable management and exploitation of tuna resources, in particular the South Pacific albacore. The national tuna management and development plan (2017 – 2021) provides the policy framework and outlines strategies for the management and development of the Samoan tuna fishery.

The albacore fishery has an annual catch limit of 4,820 mt and operates according to category limits on the number of vessels or licenses in each period. Since the introduction of locally based foreign vessels, current harvest levels are around 80% of the TAC levels for albacore in Samoan waters. Scientific advice from SPC confirms that albacore stock remains in a biologically healthy state, but that its future prospect depends on local abundance, catch rates and economics (Secretariat of the Pacific Community, 2018). Based on the catch records for the longline fishery reported to the WCPFC, yellowfin tuna on average accounts for about 20% of the catch and bigeye tuna is about 3%.[23] These are important species for the high-value exports of chilled Samoan tuna to the US and Japanese markets.

The yellowfin catches in Samoa's EEZ and by the Samoan fleet do not directly contribute significantly to the overall regional impact on the stock, however, these catches support regional measures to maintain current spawning biomass levels (Secretariat of the Pacific Community, 2018). Although bigeye catches inside Samoan waters accounts for an average of only 0.06% of the WCPFC catch, the regional catch of bigeye, including those by the Samoan fleet, are not considered sustainable at current average harvest levels.

The FAD component of the purse seine fishing catches are juvenile bigeye and yellowfin, thus impacting the stocks of these species by reducing the potential for growth. Regional catch of skipjack tuna, including those made in Samoan waters and by Samoan flagged vessels, is considered sustainable. However, Samoa needs to support regional efforts to manage the FAD component of the purse seine fishery to reduce adverse impact on its yellowfin and bigeye fishery. In addition, the resulting bycatch of sharks and marlin species has caused over-exploitation. Improving gear and technology may increase vessel selectivity but will require investment and greater enforcement of the WCPFC management measures for bycatch species.

23 Overall yellowfin accounts for about 12% of the total catch when skipjack is included from troll and purse seine.

6.2.2.6 Distribution

Both domestic and foreign fishing vessels have been fishing for tuna in Samoa's EEZ since 2015. The locally based foreign vessels and local vessels land all their catch in port in Samoa before exportation to various destinations. The frozen tuna is packed in containers and shipped mostly to American Samoa, while the fresh and chilled tuna is shipped by air to Japan, the USA and New Zealand, or sold locally. Locally based-tuna fishing benefits consumers as some vessels sell tuna and bycatch in Samoa. The locally based fleet provides employment, and their catch supports some local processing industries.

Samoa earns less benefit from vessels that land all their catch outside Samoa, as the catch does not constitute an export, is not taxed, and does not employ Samoans. The main benefit from foreign vessels is their license payment and/or the access *revenue* obtained. Fish exports benefit Samoa through foreign exchange earnings, while consumers in importing countries benefit from the supply of tuna. Catch sold locally, such as skipjack and some bycatch, benefit local communities.

6.2.2.7 Trolling

Pelagic trolling by small-scale vessels started in the 1980s in Samoa with the use of alia catamarans. These vessels were used for tuna trolling and for deepwater bottom fishing. As the fishery developed, vessels with increased length and power were constructed to venture out to the deeper oceanic areas.

6.2.2.7.1 Identify

The Fisheries Division introduced Fish Aggregation Devices (FADs) to the small-scale tuna fishery in 1979. As a result, the troll fishery for tuna increased and became the main fishing method for catching tuna in Samoa in the 1980s.

With improvement in gear and technology by the late 1990s, some vessels switched to vertical longlining and tuna longlining, thus interest in troll fishery decreased and the FAD deployment was reduced. However, with the decline in tuna longlining from 2002 to 2005, the Fisheries Division scaled up the FAD programme as more fishers reverted back to trolling for tuna (Gillett & Tauati, 2018).

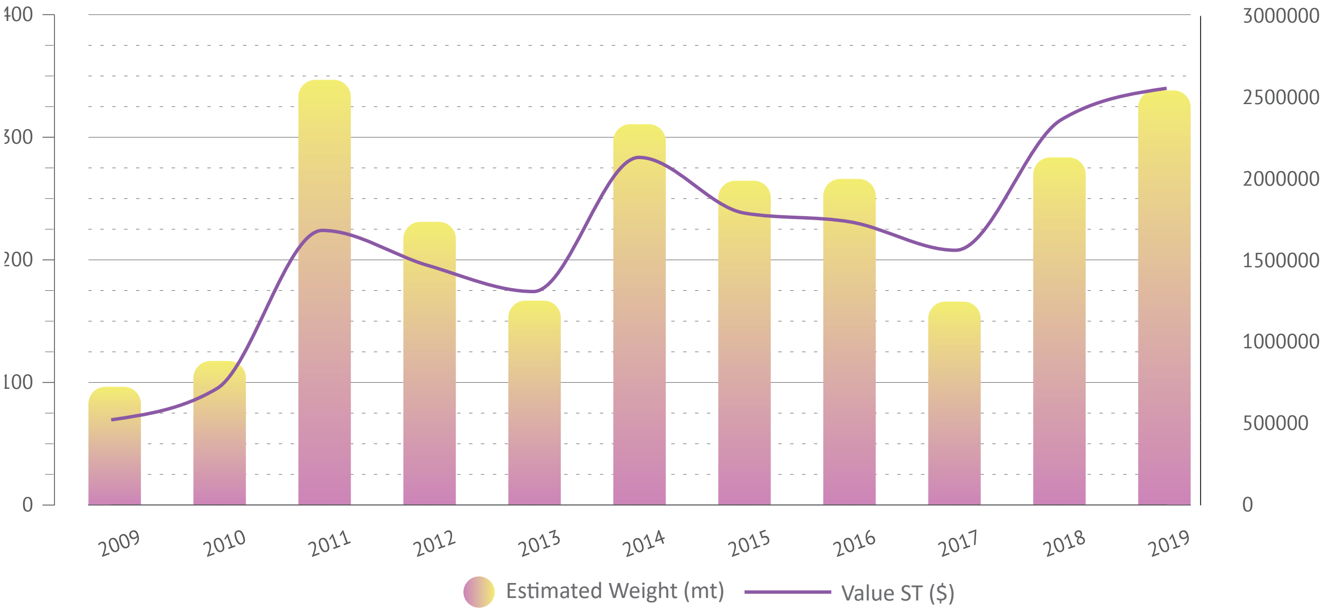
Nearshore deployment of FADs to ease coastal fishing pressure continues to be a development assistance programme provided by the Fisheries Division. Fishers benefit through reduction of their operational costs and improvements in catch rates of the alia vessels. Tuna catch rates from trolling around FADs are often three times those from chasing tuna and trolling in open waters and around reefs (Secretariat of the Pacific Community, 2013). The troll fishery involves alia fishing vessels of around 9 to 11 metres in length, which mostly target skipjack (*Katsuwonus pelamis*), yellowfin and mahi mahi. The vessels operate a few miles offshore, targeting free schools or FAD associated pelagics (Government of Samoa, 2019). The small size of the alia and their limited range restricts their time out at sea to one or two-day fishing trips (see Figure 17).

6.2.2.7.2 Quantify

Trolling for pelagic species including tuna, often occurs beyond reef areas, and thus the fishery is categorised by the Fisheries Department as 'offshore'. The vessels are less than 11 metres, undecked with outboard motors and operate between six to nine nautical miles from the coast. Therefore, fishing is characterised by artisanal techniques with the majority of the catch sold locally at the major markets, hence it falls under the domestic commercial fishery. In 2018, 42 alia vessels registered to use multi-gear, alternating between trolling, longlining and bottom fishing. Figure 18 shows a gradual increase in both catch and *value* of the troll fishery, apart from a production decline in 2013 and in 2017. The average annual catch was estimated to be 249 mt, based on Fisheries Division data for the last 10 years.

Figure 17: Typical Alia vessels used to fish around FADs in Samoa

Figure 18: Trend in quantity and value of troll fishery



Source: Fisheries Division Database, 2020.

6.2.2.7.3 Value

Specific details on the estimated costs for this fishery are not available. Using Samoa's *value-added* cost ratio of 0.8 for coastal commercial fisheries, and 0.4 for offshore locally based vessels (Gillett 2016), an average ratio of 0.6 is used as an approximation of the likely cost of operations, given that fishers go beyond the reef in search of tuna schools. The catch usually goes directly to local markets or hotels and restaurants without processing, and fishers may have their own selling arrangements with other fishers (Tolvanen, *et al.*, 2019). The gross *market values* of the catch, for 2018 and 2019 were SAT$2,363,451 and SAT$2,557,029 respectively, while the average annual production of 249 mt generated an average annual *net value* of SAT$1,039,324. The *net value* of the fishery can be estimated as SAT$1,418,070.60 in 2018 and SAT$1,534,217.40 in 2019. These estimates represent the net benefit of the fish catch to the fishing fleet, and do not include benefits from fishing licenses or post-harvest retail activities.

6.2.2.7.4 Uncertainty

It is difficult to determine the actual level of fishing effort dedicated to troll fishery in Samoa as it alternates between longline and bottom fishing. Furthermore, troll fishery may fluctuate depending on seasons and the market price of the various species caught, including tuna and non-tuna species. As noted above, cost estimates are based on *value-added* ratios rather than the direct costs incurred by fishers. The market price used by the Fisheries Division to *value* troll catch is less than SAT$9.00 per kg, while the average market price for finfish is more likely to be around SAT$12 to SAT$15 per kg. Thus, the *value* of the troll fishery is likely to be about 20% higher than the estimated *value* of SAT$1,534,217.40 for 2019.

6.2.2.7.5 Sustainability

Skipjack, which is the major catch from the troll fishery, is part of a regional stock where sustainability depends on the level of fishing pressure in the wider regional waters, including Samoa's EEZ. The regional catch of skipjack tuna, including that from Samoan waters, is considered sustainable at recent average harvest levels (Secretariat of the Pacific Community, 2018). The 12th Scientific Committee of the Western and Central Pacific Fisheries Commission concluded that the skipjack stock is not experiencing overfishing. However, FADs related to the purse seine fishery are affecting spawning biomass (Secretariat of the Pacific Community, 2018).

The purse seine fishery also catches juvenile bigeye and yellowfin, thereby reducing the potential for individuals to grow to reproductive maturity and stocks that are also targeted by the troll fishery. The annual catch of skipjack in Samoa averaged 694 mt between 2012 and 2017, representing less than 0.1% of the regional catch. Therefore, it can be concluded that localised overfishing of skipjack does not occur and scope exists for further expansion of the troll fishery.

6.2.2.7.6 Distribution

A large portion of the benefits from this ecosystem service goes to local fishers and communities. However, some fishers also benefit from selling their catch to other commercial fishers, who may export the catch either as fresh chilled fish or as frozen fish, to obtain a better price offered at the local markets.

6.2.3 Marine aquarium fishery

The collection and subsequent export of marine invertebrates and vertebrates for the aquarium trade has been an important source of income for coastal communities in some Pacific Island countries. The industry is largely based on resource extraction, therefore, the long-term sustainability and health of the resource remains a concern at the present time, although it may have some future prospects.

6.2.3.1 Identify

A small aquarium trade began in 1986 with exports of damsels, wrasses and angel fish. The trade continued until 1997, when the government issued a management directive to limit aquarium trade to the collection and export of live rock only (Wabnitz & Nahacky, 2015). Exports ceased in 1999. A private company operated a giant clam facility and collected live rock from late 1998 to 2002, targeting the marine aquarium trade and the local seafood market.

A regional review was undertaken to enhance the production of existing and new aquaculture commodities, including those for the aquarium trade such as giant clams, hard and soft corals, live rock and finfish (Lindsay,*et al.*, 2004). The study concluded that marine habitat diversity is limited in Samoa, thereby limiting the range of marine species available for culture. However, the study identified suitable locations for the culture of commodities for the marine ornamental trade.

6.2.3.2 Quantify

At present, no active aquarium trade exists in Samoa. Historical data on the production and trade of marine ornamental fishery has been unavailable.

6.2.3.3 Value

In response to industry interest in establishing an aquarium fishery, the Fisheries Division, in collaboration with SPC, undertook a study in 2015 to determine the commercial viability of the marine aquarium fishery around Upolu. The findings of the survey suggested that a sustainable and or viable industry could not be developed, even though a few areas had collectable quantities of angel fish and a variety of corals of interest (Wabnitz & Nahacky, 2015). Since there is no operational fishery and a lack of quantifiable data, it is not possible to quantify the *value* of current resources or the future potential for aquarium trade. However, the existence of ornamental resources in the coastal reef areas supporting the aesthetics of Samoa's reef biodiversity indirectly benefits locals and tourists who engage in diving and snorkelling activities.

6.2.3.4 Uncertainty

Despite the avoidance of exploitation for nearly two decades of species suitable for the aquarium trade, the viability of a marine aquarium fishery is still uncertain. Factors contributing to this include environmental impacts from land use and pollution affecting coastal areas, local transportation costs, the condition of local infrastructure, the availability of air cargo space and regular air flights necessary for the perishable nature of the commodities. Furthermore, the marine ornamental trade is sensitive to external shocks, which are then mirrored in the demand for the commodity, such as during the global financial crisis and the current COVID pandemic.

6.2.3.5 Sustainability

Several regional and international initiatives have been developed providing codes of best practice to prevent natural resource degradation and to improve individual specimen health, such as those under the Marine Aquarium Council and the Convention of Trade in Endangered Species (CITES). The global nature of trade requires reporting and compliance for species threatened under the Convention of Trade in Endangered Species (CITES) list. In the case of marine ornamentals and coral rocks, more than 2,000 species of hard corals and all species of giant clams are listed under Appendix II of CITES. Conservation and management strategies include developing management plans and culturing products. Aquaculture may reduce the need for wild resource extraction and therefore enhance the long-term sustainability of the industry in Samoa. However, aquaculture techniques for culturing marine organisms of interest targeting the marine ornamental trade are not well developed. Further investment is needed into technological development focused on animal husbandry and culture practices, as well as market research to target niche markets for aquacultured commodities.

6.2.3.6 Distribution

The producer benefits of any potential trade may be distributed among aquarium exporters and the divers and collectors who may originate from coastal communities around Samoa. Since the fishery would be export-oriented, the consumer benefit would be derived by the hobbyist in the importing country, and by the government, which is likely to accrue some *revenue* through licences, permits and taxes.

The above section considered the nature and value of various types of commercial fisheries in Samoa, highlighting how the values were derived and some of the data gaps. The next section considers provisioning services of sand and aggregate extraction.

6.3 Sand and aggregate

Sand and aggregate are either quarried from rock or mined from land or sea. Sand and aggregate have been extracted from marine areas for decades for use in the construction of buildings, roads, harbours, and for beach nourishment and protecting coastlines.

In the Pacific Island countries which have limited land and rock resources, sand and aggregate is often mined from beaches and lagoons often composed of dead coral. In some places (for example Tarawa, Kiribati) entire structures and sea walls are constructed from coral that has been broken into stackable bricks (Salcone, *et al.*, 2015). Clearly, this material provides an important service to island communities. Unfortunately, coral does not grow fast enough to be considered a renewable resource.

Beach and coral mining destroy habitat for fish, crabs and other marine species, and adversely impact important *ecosystem services* to the tourism industry in Samoa. Removal of coral can also leave coastal areas more vulnerable to erosion and storm surge inundation and lead to saltwater intrusion into groundwater. Extraction of sand from beaches and dredging of shallow ocean areas have been ongoing in Samoa over the last decade due to the growing demand from the building and construction industry for reconstruction, following several natural disasters.

6.3.1 Identify

Most beaches in Samoa are formed from coral particles broken up by storms or through coral-eating fish, and washed ashore by waves and currents, while some are also formed by particles carried from inland areas by rivers (Ministry of Natural Resources and Environment, 2013). Coral sand for concrete presumably used since the 1980s in Samoa was found to be cheaper than crushed rock sand, and did not pose land alienation issues (Vines, 1982). Solomon has described beach mining and dredging adjacent to the Mulinuu Point in the 1980s to 1990s (Solomon, 1994).

A more recent study on the adverse impacts of sand dredging along the coastal waters of Fuailoloo village is discussed by Imo *et al.* (Imo,*et al.*, 2018). Beach mining has been associated with coastal erosion in many small Pacific Island countries, particularly near urban centres in Tuvalu, Nauru, Tonga, Kiribati and the Federated States of Micronesia (McKenzie, *et al.*, 2006).

Sand is extracted for commercial and private or individual use in Samoa. Commercial extraction is conducted by companies producing cement and concrete, and to supply building materials such as Apia Concrete Products, Ulia Construction Limited & Ulia Certified Concrete, and Ah Liki Construction. Individual extraction is conducted by community groups, families or individuals for private construction work. Information on the extraction activities by the different groups, and information on the location of the sites is unavailable. Data on total available sand and sand migration patterns in different locations is also not available, neither is information on consumer demand and supply of sand.

The Ministry of Natural Resources and Environment (2013) noted that anecdotal information suggests that exploitation levels are likely to be higher than those formally approved and reported. For example, the increase in the number of businesses in the construction industry can be seen as an indicator of the likely demand for sand and aggregates.

In 2012, 167 enterprises operated in the construction industry, which rose to 255 in 2018 (Bureau of Statistics, 2020). Some Community Integrated Management Plans have also noted erosion occurring in their areas caused by sand mining (MNRE, 2018 a; MNRE, 2018 b).

6.3.2 Quantify

The MNRE regulates the mining of sand through a permit system that is supported by environmental resource assessment (Ministry of Natural Resources and Environment, 2013). The Land Development Division is responsible for overseeing sand mining activities, as well as monitoring illegal sand mining and processing applications. However, due to limited capacity and resources, the Ministry is challenged in enforcing permit conditions, such as monitoring the actual level of sand and aggregates mined. Sometimes conflicts arise due to the customary ownership nature of land where communities believe the ownership of land extends to the coastal beaches below the high-water mark (Ministry of Natural Resources and Environment, 2013). Information on the number of permits and *revenue* received has been collected by MNRE.

Dredged sand, coral chips and crushed coral chips are commodities commonly sold by concrete manufacturing companies, indicating that marine extraction of dead coral and sand are ongoing activities in Samoa. However, details on the extent of aggregates taken from rivers and coastal areas are only available as aggregated data.

6.3.3 Value

The number of permits for sand mining is shown in Table 13. However, these permits do not distinguish between river sand and marine sand and aggregates. The Table indicates that the number of permits issued over the years has been variable. For example, data is not available for 2011, a decline in permits occurred in 2012/2013, an increase in 2014/2015, and another decline occurred in 2015/6. *Revenue* derived from the permits is presented in Table 14.

Table 13: Number of permits issued for sand mining in Samoa between 2008 - 2018

Fiscal Year	No of commercial permits	No of individual permits	Total permits issued
2008/09	19	51	70
2009/10	13	53	66
2010/11	16	49	65
2011/12	NA	NA	NA
2012/13	18	8	26
2013/14	8	34	42
2014/15	16	42	58
2015/16	10	23	33
2016/17	7	27	34
2017/18	11	32	43
NA – Not available			

Source: Ministry of Natural Resources and Environment, 2013; MNRE Annual Reports (2012/13 – 2017/18).

Table 14: **Revenue from issue of sand mining permits in Samoa between 2012 – 2019**

Fiscal Year	*Revenue* from commercial permits (SAT$)	*Revenue* from individual permits (SAT$)	Total *revenue* from permits (SAT$)
2012/13	33,620	3,500	37,120
2013/14	10,200	2,575	12,775
2014/15	16,050	3,490.85	19,326.85
2015/16	13,385	1,555	15,290
2016/17	19,560	1,705	21,265
2017/18	12,820	3,115	15,935
2018/19	24,400	2,030	26,430

Source: MNRE Annual Reports (2012/13 – 2017/18).

Figure 19: Average price of sand mining permits in Samoa 2012 - 2018

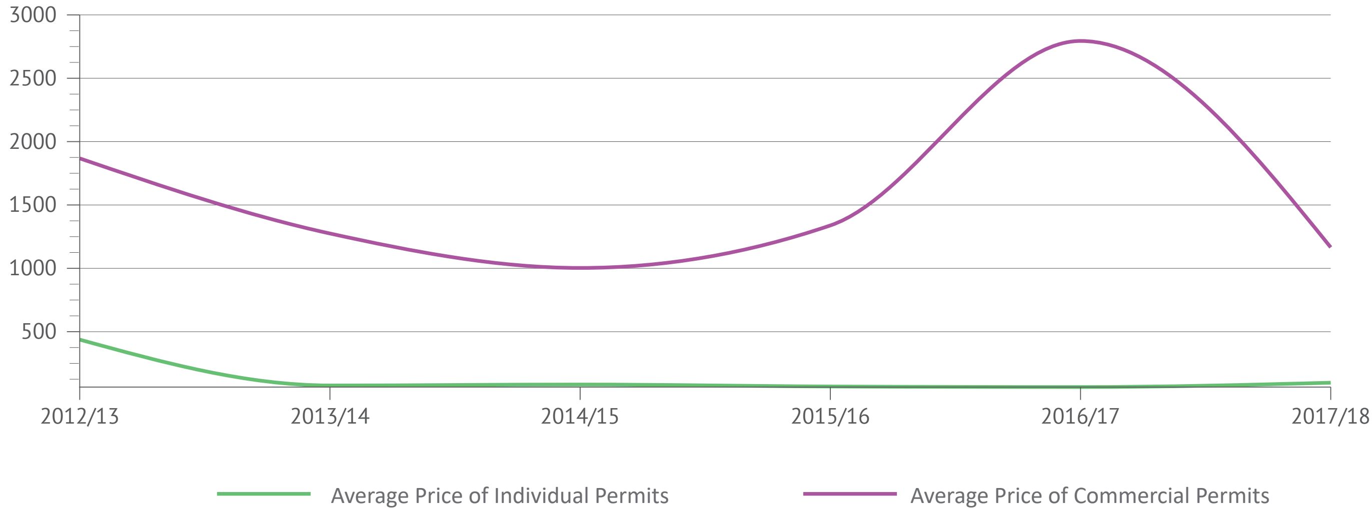


Figure 19 shows the average price of commercial permits is much higher than for individual permits. Prices vary depending on the specific type of sand and place of mining, but such information is not available in the public domain. The total *revenue* derived from sales of sand permits in the 2018/19 period was SAT$26,430. This amount is an under-estimation of the *value* of this *ecosystem* service as it is not known how much sand was extracted.

The *revenue* estimates above reflect the benefits received by the MNRE, not the societal benefits, which would require estimating the benefits to consumers of sand and aggregate in construction activities. Furthermore, to accurately estimate the true *economic value* of this *ecosystem* service, the negative externalities from beach mining and dredging should be subtracted from *net revenues*. This would require a very specific CBA involving the collection of geological and socioeconomic data i.e. a study of the environmental damage, and the communities or households that would suffer the consequences of the damage).

6.3.4 Uncertainty

Significant data gaps exist with regard to the quantity of sand, the type of sand and location of the activity, the direct cost of sand collection, and the environmental and community impacts. The revenue from permits is an estimate of the benefit of sand and aggregate mining to the MNRE/government. This is one way of ensuring a degree of control to avoid sand and aggregate from becoming a public good, and consequently open to outright exploitation. Significant uncertainty exists around the negative externalities of this activity, such as those relating to the social and environmental costs from damages caused by beach mining as experienced in Kiribati and Tuvalu, which renders a true economic *valuation* very difficult.

6.3.5 Sustainability

The demand for sand and aggregate is likely to increase in accordance with the rise of economic development and population. Strengthening environmental regulations and effective enforcement is necessary, as well as other initiatives such as working with village chiefs and other stakeholders, including coastal hotel and resort owners, and increasing their and the broader public's environmental awareness about the dynamics of coastal natural processes.

Beach mining on small islands has so far been unsustainable. The removal of sand and aggregate material from beaches can increase rates of coastal erosion, induce saltwater intrusion into groundwater aquifers, damage beach and associated ecosystems and leave adjacent areas more vulnerable to coastal flooding. In view of these negative consequences, small island nations should support dredging operations that source construction material from offshore areas, and not from beaches, reefs, and lagoons. These areas should be chosen carefully to mitigate disturbance of important fishing areas or reproductive habitats of fish and invertebrates.

Small-scale beach mining could be economically sustainable in less populated areas, assuming the impact of operations on coastal processes is understood and the benefits can continue to outweigh the costs. Conversely, costs may quickly outpace benefits for larger mining operations or for frequent small-scale beach mining in more densely inhabited areas. Therefore, the sustainability of beach mining must be *evaluate*d on a case-by-case basis.

6.3.6 Distribution

Benefits from sand and aggregate mining in Samoa accrue to MNRE/government, the individuals and businesses that use the materials in construction projects (producers), and the consumers who receive the benefits from the construction projects which use sand and coral products.

6.4 Deep sea minerals

Three main types of deep-sea mineral (DSM) deposits exist containing iron, manganese, copper, zinc, cobalt, nickel, silver and gold. These are manganese nodules, cobalt-rich crust (CRC) and seafloor massive sulphides (SMS). Manganese nodules are a lump of minerals which cover areas of the seabed in the Pacific Ocean at depths below 3,500 m. Cobalt-rich crusts are incrustations of minerals that form on the sides of submarine mountain ranges and seamounts, while seafloor massive sulphides accumulate mainly at the opening of hot vents on the ocean floor.

With a growing international demand for metals and industrial minerals to manufacture consumer goods and machinery, some countries are keen to consider mining such resources from the ocean. The Pacific is seen as a region of immense deep-sea mining potential. Proponents of deep-sea mining argue that it could yield far superior ore to land mining, with little waste product and that the industry is worth billions of dollars. It could assist in the transition to a renewable energy economy, supplying raw materials for key technologies such as batteries, computers and phones (Doherty, 2019).

On the other hand, environmental and legal groups argue that there are potentially massive, and unknown, ramifications for the environment and communities, and that existing regulatory frameworks are deficient (Doherty, 2019). Little is known about the DSM reserves, costs of extraction and environmental and social externalities. Some deep-sea mining operations are underway, but most remain in the exploratory phase. Some Pacific Island countries have expressed interest in further exploration of their Exclusive Economic Zones. However, Nautilus Minerals of Canada's Solwara 1 project in Papua New Guinea's Bismarck Sea, which is the world's second deep sea mining venture, has been suspended due to community resistance, legal challenges and funding difficulties.

The Geoscience Division of the SPC (formerly known as South Pacific Applied Geoscience Commission (SOPAC)) has produced a number of technical reports, studies and guidance documents on the costs and benefits and legal issues relating to deep sea-bed mining. The Geoscience Division of SPC provides policy advice and technical assistance to Samoa to help develop its legal and regulatory framework on deep seabed mining to guide government decision making.

6.4.1 Identify

The Samoa Island chain consists of high volcanic islands, atolls and submerged reef banks, and seamounts near the southwest margin of the Pacific plate. The chain trends in a south-eastern direction, and the islands are volcanically active on both the eastern and western end of the chain (SPC/Applied Geoscience and Technology Division, n.d.). Samoa's EEZ is the smallest in the region and its seafloor topography is divided into abyssal plain, mountainous zone and the Tonga Trench.

SOPAC was engaged in deep sea mineral exploration in the region between the early 1970s to mid-2000 in partnership with Pacific Island countries and multinational agencies. Deep sea mineral investigation in Samoa, therefore started in the late 1970s to assess the potential for manganese nodules, phosphate, precious corals and cobalt-rich crusts (CRC). Table 15 provides details of the mineral explorations that occurred in Samoa's EEZ.

Table 15: Summary of deep-sea mineral exploration in Samoa

Research vessel and year of survey	Survey area	Surveyed commodity
R V Coriolis (1977)	Samoa's EEZ	Manganese nodules
R V Machias (1979)	Pasco Bank West of Savai'i, and shallow bank northeast of Pasco Bank	Precious coral, Phosphate
R V Machias (1979)	Assau and Salelologa Harbours	Nearshore sediment deposits to construction and landfill
R V Machias (1979)	South (to the Tonga Trench) and west of Upolu and Savai'i	Precious coral, manages nodules/crust, Phosphate
R V Machias (1980)	Deeper flanks of the Samoa Island slope	Precious coral
R V Moana Wave (1987)	Machias Seamount, southern coast, and the western tip of Savai'i	Cobalt-rich crusts, metalliferous sediments, hydrothermal vents
R V Hakurei Maru 2 (1990)	Sea area of Upolu and Savai'i	Manganese nodules, Cobalt-rich crusts

Source: (SPC/Applied Geoscience and Technology Division, n.d.)

The 1979 survey results concluded that there was little potential for manganese nodule deposits of any significance in Samoan waters (SPC/Applied Geoscience and Technology Division, n.d.). A survey in 1987 suggested that Savai'i is probably geologically too young, and the surrounding sea-floor is too unstable for thick CRC to have formed. During the 1990 survey, CRC was found on four seamounts.

The results of the exploration studies suggested a moderate potential for CRC, but the grade of manganese nodules was low. In addition, the water depth within Samoa's EEZ is about 4,600 – 4,800 meters which were considered relatively shallow for mineral formation.

Exploratory studies concluded that deep sea mining was not economically viable for Samoa, given the knowledge and technology available during the 1970s to 1990s and against the backdrop of the global mineral market conditions.

In light of the lack of current information and improvements in science and technology, Samoa's Ocean Policy notes the need to further re-visit research on the seamounts of Samoa to better understand their ecological processes and functions (Government of Samoa & Conservation International, 2019, p. 41). In Samoa, any mining of seamounts will require a careful assessment of its impact on fisheries, such as the deepwater demersal species. The seamount surface is typically dominated by filter feeders like corals and sponges fixed to the hard substrates. These organisms influence the existing ecosystem structure by forming reefs that attract more organisms, including crustaceans, molluscs and echinoderms (Cuyvers, *et al.*, 2018).

Seamounts are also important for free-swimming organisms. Many animal species that live on or near seamounts are characterised by extremely slow growth rates and by producing relatively few offspring (Miller, *et al.*, 2018). Fish and marine mammals also aggregate over seamounts either for foraging or resting. Besides supporting turtles and cetaceans for feeding, seamounts are thought to be navigational features during migration and breeding (Miller, *et al.*, 2018). The Samoan Archipelago has been identified as an important Marine Mammal Area,24 which is important to note in light of Samoa's tourism industry that attracts visitors for whale and dolphin watching and swimming with turtles.

6.4.2 Quantify

Sixteen seamounts have been identified in Samoa's EEZ (Ministry of Natural Resources and Environment, 2013, p. 68). During the 1990 Japan-SOPAC survey of Samoa, manganese nodules on the sea-floor and CRC were investigated on four seamounts. Table 16 presents the estimate of crust and metal resources in the four seamounts in the EEZ of Samoa.

The above table shows that a total of 2 million tonnes of inferred crust resources was estimated to have occurred within the EEZ of Samoa. Cobalt, Nickel and Copper resources were estimated at 8,100 tonnes; 4,600 tonnes and 1,700 tonnes respectively. The exploratory study noted that conditions for the growth of manganese nodules were present, but the accompanying presence of turbidite sediments inhibited nodule formation, and the thin crust was due to the young age of the substrate. No other reports or updates were available apart from the SPOAC study for Samoa.

24 https://www.marinemammalhabitat.org/portfolio-item/samoan-archipelago/ (accessed 6 September 2021); per.com Karen Baird, Secretariat of the Pacific Regional Environment Programme.

6.4.3 Value

In general, the net benefit of deep seabed mining from licence and tax *revenues* and employment would depend on the market price of mineral extraction deducted by extraction costs and the cost of negative externalities. More specifically, the costs of deep seabed mining comprise: the *financial costs* associated with the mining process (including innovation costs, and up-front capital expenditure on design, construction, testing, maintenance and processing), intangible costs such as long-term impacts from the degradation of marine ecosystems, and costs associated with developing and enforcing regulations and environmental mitigation (Cuyvers, et.al., 2018).

Alternatively, some researchers look at the seabed ecosystems in a broader context and argue that seabed benefits must extend beyond its mineral resources to include its substantial contribution to biodiversity and climate regulation. Such contributions may be less quantifiable in terms of projected *revenues*, but indispensable to human life (Hunter, et.al., 2018). Despite progress in the development of a regulatory framework by the International Seabed Authority (ISA), and advances made by mining companies in the science and technology of deep seabed mining, there is a growing contention that the long-term environmental risks of this activity need to be better understood before any commercial deep-sea mining commences.

Table 16: Estimation of crust and metal resources within the EEZ of Samoa (1990).

Seamounts	Inferred resources (tonnes)	Metal resources (tonnes)		
		Cobalt	Nickel	Copper
SD01	881,000	2,909	1,763	705
SD02	914,000	4,387	2,376	822
SD03	211,000	864	484	147
SD04	14,000	-	-	9
Total	2,020,000	8,160	4,623	1,683

Source: (SPC/Applied Geoscience and Technology Division, n.d.)

Since deep sea mining exploration or mining activities are not currently undertaken in Samoa's EEZ, and much of these areas are yet to be explored, the *value* of Samoa's deep sea resources cannot be estimated. Any estimation effort would lead to an undervaluation.

6.4.4 Uncertainty

The benefits of deep seabed mining compared to its long-term costs remain largely unknown due to limited examples from which to draw lessons, and much information is at an experimental level. In light of the experience of mining on land in Papua New Guinea (Flier & Le Meur, 2017; Pryke & McLeod, 2020) and the case of the Solwara I Project (Slatter, 2020; Doherty, 2019) which faced financial and legal challenges as well as community resistance, it can be deduced that a high level of uncertainty surrounds deep seabed mining.

Furthermore, scientists argue that deep sea biodiversity and ecosystems remain under-studied and poorly understood. This lack of information makes it impossible to properly assess the impacts of mining and establish adequate safeguards against likely pollution, disturbance of seafloor ecosystems, sediment displacement, noise vibration, and light (Doherty, 2019). There is a high degree of uncertainty associated with realising the *economic benefits* of mining the seabed due to limited understanding and knowledge of the deep sea ecosystems and habitats, and their *values* (Armstrong, *et al.*, 2012; Cuyvers, et.al., 2018).

6.4.5 Sustainability

Mining is necessary to produce minerals and rare earth elements used in a wide range of industries. Since deep sea mineral deposits are generally considered as finite resources, they are non-renewable and therefore ecologically unsustainable. Ensuring long-term equitable benefits flow from mining will require formulating appropriate *revenue* management mechanisms such as trust funds or benefit sharing arrangements to avoid future social conflicts.

The extractive nature of the industry also carries the risk of irreversible environmental consequences. Any proposal to explore or develop areas must apply a precautionary approach (World Bank , 2017) together with a thorough *cost benefit analysis* (Secretariat of the Pacific Community, 2013).

A number of PICTs have called on the international community for a 10-year moratorium on deep sea mining in light of concerns about our limited understanding and knowledge of deep-sea ecology and habitats for marine fauna and flora, and the role of the deep-sea *ecosystem services* in climate regulation for example (Chin & Hari, 2020). These concerns are also relevant to Samoa, given the high reliance of the economy on marine-based tourism and fisheries resources that may be adversely impacted by disturbance to its seamounts.

6.4.6 Distribution

In principle, there are two areas of seabed mining: the area within a country's EEZ, and the area outside it (known as the 'common heritage of mankind' or the 'Area'). In the first case, the nation state is responsible for regulating the mining activity. In the second, the resource is shared amongst all nations, centrally managed by the International Seabed Authority which grants licenses for specific areas.

As the mining operations are likely to be foreign-owned, most of the *producer surplus* (*profit*) will be received by foreign companies and the consumers who benefit from lower cost metals and minerals. The benefits of mining operations in Samoa's EEZ would likely accrue to the government in the form of licence fees, taxes, and royalties. These benefits could be redistributed to communities through improved social programs, infrastructure, or other public services. Although potential employment opportunities for Samoans could result, most employment will be for highly specialised ocean miners.

6.5 Tourism and recreation

Marine and coastal ecosystems offer a variety of passive and active recreational activities that attract locals and tourists to Samoa. Recreational activities provided by the sea, reef, lagoon and beach areas include a wide range of pursuits such as swimming, diving, snorkeling, fishing, recreational gleaning, kayaking, canoeing, surfing, jet skiing, whale/turtle watching, charter boats, cruise ships, beach activities and simply enjoying the environmental aesthetics. The participants in, or consumers of, marine and coastal tourism and recreation are diverse originating from nearby communities, other parts of Samoa, or other countries. Therefore, tourism and recreation can be further categorised into international tourism, and domestic recreation and tourism. International tourists include visitors from other countries and Samoans who live overseas and hold foreign residency and are visiting temporarily, while domestic tourism is travel outside the 'usual environment'. It includes travel within one's own island if staying in commercial accommodation, and visiting other islands for overnight trips such as from Upolu to Savai'i, and vice versa (Samoa Tourism Authority, 2015).

Opportunities for tourism are dependent on two things: the natural and cultural amenities that people find attractive, and the human-made amenities that support travel, accommodation, and recreation (Arena, *et al.*, 2015). The extent to which tourism and recreation are considered *ecosystem services* depends on the extent these activities rely on the natural ecosystems. For example, snorkeling and diving are activities that are almost entirely dependent on the state of the *ecosystem* in question. Individuals snorkel and dive to appreciate a healthy coral reef that has a rich biodiversity. The more interesting coral and variety of fish there are to see, the more likely tourists will be attracted to the activity.

It can be extrapolated that tourism demand is not only influenced by infrastructure, distance, and availability of substitutes, but also by the quantity and quality of the environmental characteristics. For example, understanding the full *value* of coral reefs to tourism, and the spatial distribution of the *value* provides an important incentive for sustainable reef management (Spalding, *et al.*, 2017).

6.5.1 International tourism

Tourism has become a high priority for development in Samoa after the devastating cyclones of the 1990s which caused huge damage to the agricultural sector, and the problems caused by the taro blight and African snail (Tagomoa-Isara, 2010). Since then, tourism has made a significant and continuing contribution to the Samoan economy. International tourism is seen as a lifeline for many small Island Developing States (United Nations World Tourism Organisation, 2020), given their limited opportunities for other exports such as agriculture and manufacturing. International tourists visit Samoa for holidays, business, connecting with friends and relatives, and for other purposes such as attending conferences, sports and research.

Exports *revenue* from international tourism in Samoa was 22% of GDP and represented 58% of the total export *revenue* in 2018 (United Nations World Tourism Organisation, 2020). The Samoan Tourism Authority markets its tourism products and services as having a 'Samoan Experience,' which is a blend of traditional Samoan culture, pristine natural environment, and a safe, relaxing and welcoming social environment, complemented by its attractiveness as a tropical island with sun, sand and surf (Ministry of Natural Resources and Environment, 2015). Indeed, there is a heavy reliance on the marine and coastal zone to support such expectations and aspirations. For example, 70% of all resorts are located along the coast (Craymer, 2013) and offer a range of water-based activities and attractions. See for example, Figure 19 and 20.

6.5.1.1 Identify

In small island economies, Gross National Income (GNI) per capita can be broadly used as an economic indicator of the correlation between international tourism *value* and marine and coastal ecosystems services *value*. The annual GNI per capita of countries with well-developed tourism industries such as Palau (US$17,280) and Fiji (US$5,860), are much higher than countries with less developed tourism sectors such as Kiribati and the Solomon Islands (US$3,350 and US$2,050). Using data from 1990 to 2007, a study of 19 island economies highlighted a two-way relationship between tourism growth and economic growth (Seetanah, 2011). The GNI per capita for Samoa in 2002 was US$1,520 compared to the GNI per capita in 2019 of US$4,180 (World Bank, 2020).

Samoa markets its attractions as a diver's paradise, with an abundance of marine life, crystal clear waters, numerous reefs, and shipwrecks. In 2002, the entire EEZ was declared a sanctuary for turtles, dolphins, sharks and whales (Ministry of Natural Resources and Environment, 2013). Divers can encounter reef sharks, sting rays, moray eels, and spectacular corals. The Palolo Deep Marine Reserve covers an area of 137.5 ha of fringing reef with a hole surrounded by walls of corals and tropical fish. It is located close to Apia harbour and attracts many international tourists for diving, snorkeling and research.

The Southern part of Upolu Island has several vibrant beach fales along a beautiful sandy stretch, with idyllic ocean views, such as the Lalomanu and Saleapaga Beaches. The southern beaches of Upolu and Savai'i have consistent surf all year, with swells between 2-15 feet. The To Sua Ocean Trench and the Piula Cave pool also draw tourists interested in swimming (Samoa Tourism Authority, nd 1).

A ferry service to the island of Savai'i from Upolu takes about an hour. Savai'i boasts a number of beach *fales* and coastal ecotourism-related activities that draw tourists. Four of the top five attractions on the island are coastal based i.e. Salelologa beach, Alofaaga blowhole, Saleaula Lava field and Siufaga beach, where swimming with turtles can be experienced (Samoa Tourism Authority, nd 2). Similarly, the six most popular attractions on Upolu are coastal based.

Figure 20 and 21 show maps of Upolu and Savai'i, and the main coastal attractions identified by tourists (Samoa Tourism Authority, nd 2). Most of the accommodation is located close to the coastal areas within easy access to beaches, lagoons, reefs and oceanic areas to capitalize on these attractions. The resorts and hotels directly offer or facilitate other water-based activities including, kayaking, charter fishing, surfing, jet skiing, canoeing, and whale watching.

Figure 20: Major attractions for tourists on the Island of Savai'i

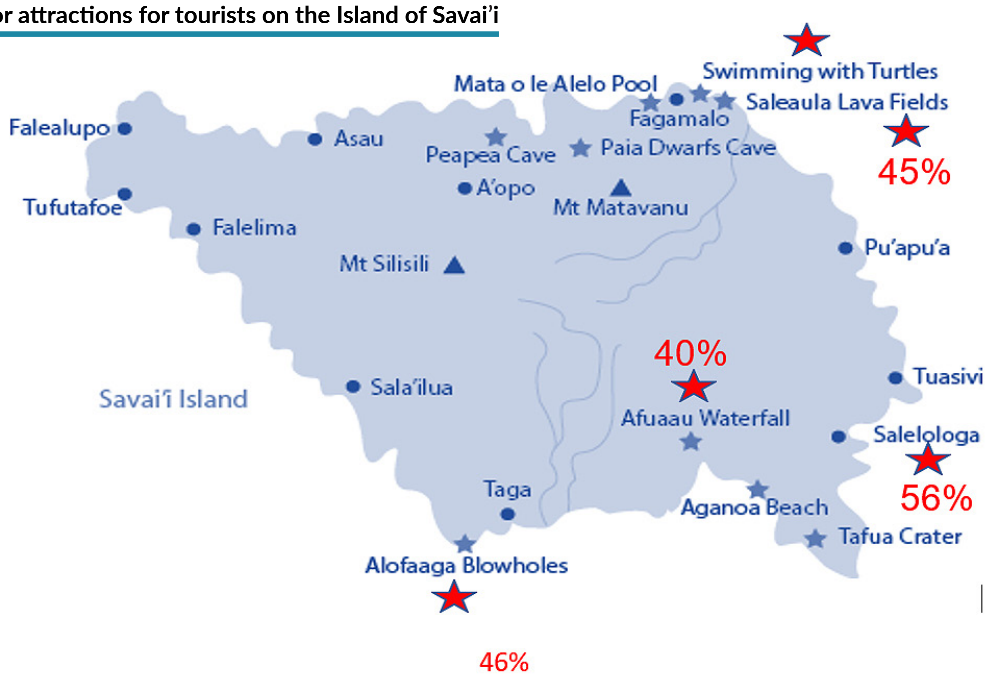
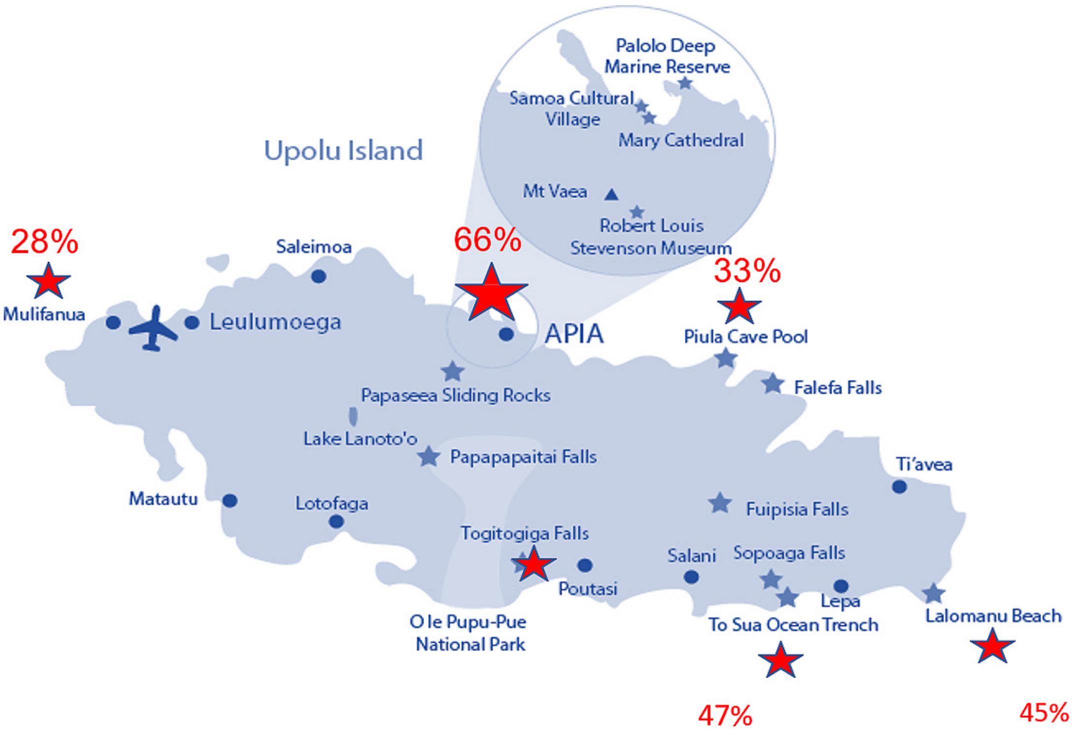


Figure 21: Major attractions for tourists on Upolu Island



Source: Samoa International Visitor Survey, 2018

Several eco-tourism activities are also operated by households and village committees. Many communities have village fish reserves and MPAs such as the Aleipata and Safata marine reserve, where non-extractive activities are allowed at a *nominal* fee. Samoa's marine and coastal ecosystems provide real and measurable benefits to international tourists, locals and tourism businesses.

Tourism requires marketing, infrastructure, accommodation, transport and effective communication systems. The connected group of industries consists of closely associated and interacting segments including transport, accommodation and intermediaries like tour operators, travel agents, catering services, retail such as for souvenirs, local attractions and activities and vehicle rental (Hampton, *et al.*, 2018).

Samoa has direct flights from Australia, New Zealand, Fiji, the USA and American Samoa, and easy connections to Asia and Europe.[25] It has a well-established primary market in Australia, New Zealand and American Samoa, while the USA and Europe are secondary markets and Asia is an emerging market (Samoan Tourism Authority, 2014). The tourism sector plan (2014- 2019) outlines goals and objectives and provides policy guidance for sustainable tourism management and development. The Samoan Tourism Authority is the government agency responsible for coordination of the tourism sector, including addressing government and investors on tourism development issues.

Samoa is a unique country because more Samoans live overseas than in the country. This motivates Samoans to travel, incorporating mobility, rooted in the concept of 'malaga' (meaning travel back and forth), within the Samoan social life. For Samoans, travel maintains cultural bonds as part of 'fa'alavelave' (traditional obligation) and familial support through visiting friends and relatives (Gibson, *et al.*, 2020). Hence, the marketing of tourism products involves promoting the social, cultural and environmental dimensions of travel to meet market demand.

Efforts are made to integrate local, regional and national tourism-related activities. For example, Samoa is divided into six Tourism Development Areas with individual tourism management plans. The plans prioritise adaptive measures through community input, and integrate climate change adaptation and disaster risk management measures as part of an holistic approach to local area tourism development.

25 Assuming that things will gradually return to previous arrangements once the COVID-19 Pandemic restrictions are lifted.

In many cases, local communities have become suppliers of tourist products (accommodation, food, transport, guide services), generating backward and forward economic linkages. These linkages can expand the local supply chains and further stimulate local innovation and businesses such as restaurants, handicraft and souvenir shops, internet cafes, and massage and relaxation therapy.

A number of local initiatives that help facilitate tourism development are being conducted in each of the six areas. For example, on Manono Island, the village has identified its priorities as seawall repair through coastal vegetation to protect the coastline, and coral seeding to improve the function of the reef as a protective barrier, as well as diversifying tourism products such as increasing village-based experiences for visitors (Samoa Tourism Authority, 2015 a).

In the South-East Upolu area several beach *fales* had issues with the movement of sand on the beach, so the management plan included banning sand mining and introducing revegetation of coastal areas (Samoa Tourism Authority, 2015 b). In addition, the government is currently developing the Apia waterfront, and expanding the port area and marina to better accommodate cruise ships. The Tourism Development Plan also outlines other efforts by the government to support tourism in Samoa, such as streamlining incentives to attract investors, and upgrading infrastructure. In summary, tourism is regarded as a growth sector for Samoa that capitalises on the main attractions of the country's culture and marine environment, supported by a well-developed institutional framework, infrastructure, and communications network.

6.5.1.2 Quantify

Approximately 172,496 international tourists visited Samoa in 2018: 167,651 by air and 4,845 by sea (Bureau of Statistics, 2020). Table 17 shows a breakdown of different types of visitor arrivals by main purpose of travel between 2014/15 and 2018/9. Although there has been a steady increase in holiday visitors, visiting friends and relatives (VFR) was the primary driver in 2018 fiscal year.

The major market for visitors in 2018 was New Zealand (47.1%), Australia (21.2%), American Samoa (9.1%), USA (8%), Asia (4.5%) and others (10.1%) (Bureau of Statistics, 2020). According to the Samoa Tourism Authority, the total overnight visitor expenditure was estimated as SAT$514.1 million in 2018, compared to SAT$414.1 million in 2017, resulting from an increase in international visitors (Samoa Tourism Authority, 2020). The total inbound tourism

Table 17: Main purpose of travel to Samoa by international visitors

Purpose	2014/15		2015/16		2016/17		2017/18		2018/19	
	No of people	%	No of people	%	No of people	%	No of people	%	No of people	%
Holiday	47,180	35	55,611	38	58,010	40	64,734	40	68,886	39
VFR	44,085	33	48,113	33	48,076	33	63,465	39	71,980	40
Business	12,974	10	12,093	8	12,515	9	10,508	6	10,934	6
Sports	1,175	1	2,588	2	1,377	1	1,522	1	1,622	1
Others	27,656	21	27,699	19	26,459	18	23,094	14	25,142	14
TOTAL	133,070	100	146,104	100	146,437	100	163,323	100	178,564	100

Source: Samoa Tourism Authority 2018-2019 Annual Report; p.50.

expenditure over the GDP in 2018 was 22.4% and 72.6% over exports of services (World Tourism Organisation, 2019), and about 58% of the total share of exports. Foreign exchange earnings of SAT$514.1 represent 77% of credits for Services in the Balance of Payments in 2018.

An international visitor survey conducted by STA in 2018 estimated that the average expenditure per person per visit was about SAT$2,649 with an average length of stay around 8.2 nights. Table 18 gives a breakdown of visitor expenditure by purpose of visit (Milne *et al.*, 2019). The table illustrates a steady increase in total expenditure by VFR category. This relates to expenditure in informal accommodation and family Fa'alavelave.

In 2018, employment in accommodation and food service activities as a share of total employment represented about 5.6% (UNWTO, 2020). In 2012, employment was about 5,000 full-time and part-time jobs which represented just over 10% of total employment (Samoa Tourism Authority, 2014, p. 5).

Tourism impacts jobs in other sectors, even though the employee may be only partially involved in tourism activities. A broad definition of jobs that support tourism activities can include health, transport, information and communication. This broader definition will increase the employment figures, although it should be noted that the occupations also provide services to the resident population. For example, the inclusion of industry employment data, such as employment in accommodation and food services activities, transport and storage, information and communication, and other service activities gives an employment figure of 7,457, which represented about 18% of the total formal employment in Samoa in 2017 (Bureau of Statistics, 2017).

Table 18: International visitor expenditure by purpose of travel (SAT$ million)

Purpose	2014/15		2015/16		2016/17		2017/18		2018/19	
	SAT$ (m)	%	SAT$ (m)	%	SAT$ (m)	%	SAT$ (m)	%	SAT$ (m)	%
Holiday	125.06	36	146.90	38	155.18	40	177.64	39	191.91	37
VFR	135.42	39	146.76	38	147.37	38	199.42	44	235.18	46
Business	39.71	11	36.82	10	38.52	10	33.00	7	34.79	7
Sports	2.98	1	7.42	2	3.62	1	3.84	1	4.13	1
Others	44.35	13	47.19	12	42.94	11	40.31	9	48.06	9
TOTAL	347.5	100	385.1	100	387.6	100	454.2	100	514.1	100

Source: Samoa Tourism Authority 2018-2019 Annual Report; p.50.

An *economic impact* analysis of the Samoan tourism sector noted that inbound tourist receipts for 2013 were SAT$345 million, while data from the Central Bank of Samoa estimated the foreign exchange earnings from tourism as SAT$315 million for the same period.[26] Table 19 compares summary results from the 2013 study to estimated data for 2018 which shows expansion of the tourism sector over the five-year period.

26 The difference is due to the higher estimate solicited from the surveys which also recorded expenditure from tourists that goes to the informal sector such as accommodation and Fa'alavelave.

The 2018 Samoan International Visitor Survey noted that about 76% of visitors used hotels and resorts as their accommodation, and 15% used beach *fales* (Milne, *et al*., 2019). According to data from the Samoan Tourism Authority in January 2020, 28 tour operators and six water activity-based tour operators were in business. In February 2020 150 accommodation facilities operated. These included deluxe and superior standard type hotels & resorts (26), standard hotels, guest house, bed and breakfast, beach resort type (34), budget type with beach villas, beach bungalows, backpackers (43), beach *fales* for overnight stays (24), holidays homes (5) and beach *fales* for day visits (17).

Table 19: *Economic impact* of the tourism sector in Samoa in 2013 and 2018

Item	2013[1] (SAT$ m)	2018 (SAT$ m)
Direct tourism expenditure[2]	370 m	543.8 m [3]
Direct and indirect tourist expenditure	468 m	685.2 m [4]
Official GDP of Samoa	1,854 m	2,156.4 m
Direct tourist expenditure as % of GDP	20%	25%
Direct and indirect tourist expenditure as % of GDP	25%	31.8%
Tourism direct *gross value* Added (TDGVA)	165 m	242 m [5]
Tourism direct and indirect *gross value* added	211 m	304.9 m [5]
Tourism direct *gross value* added as % of GDP	9%	11%
Tourism direct and indirect *gross value* added as % of GDP	11%	14%

1. Economic Impact Analysis Report (2013-2014)
2. Includes inbound tourists (SAT$345 million) plus domestic tourists (SAT$22 million) plus cruise visitors (SAT$3 million).
3. This is estimated by applying the average growth rate of the Samoan population and average inflation rate between 2013 and 2018 to determine domestic tourist expenditure using data from the 2013 Economic Study. This gives domestic tourist expenditure of SAT$29.7 m, which is added to SAT$514.1 m of international tourist expenditure.
4. Multiplier of 1.26 is used from the 2013 study.
5. Using estimated intermediate consumption cost of 55.5% from 2013 Economic Study.

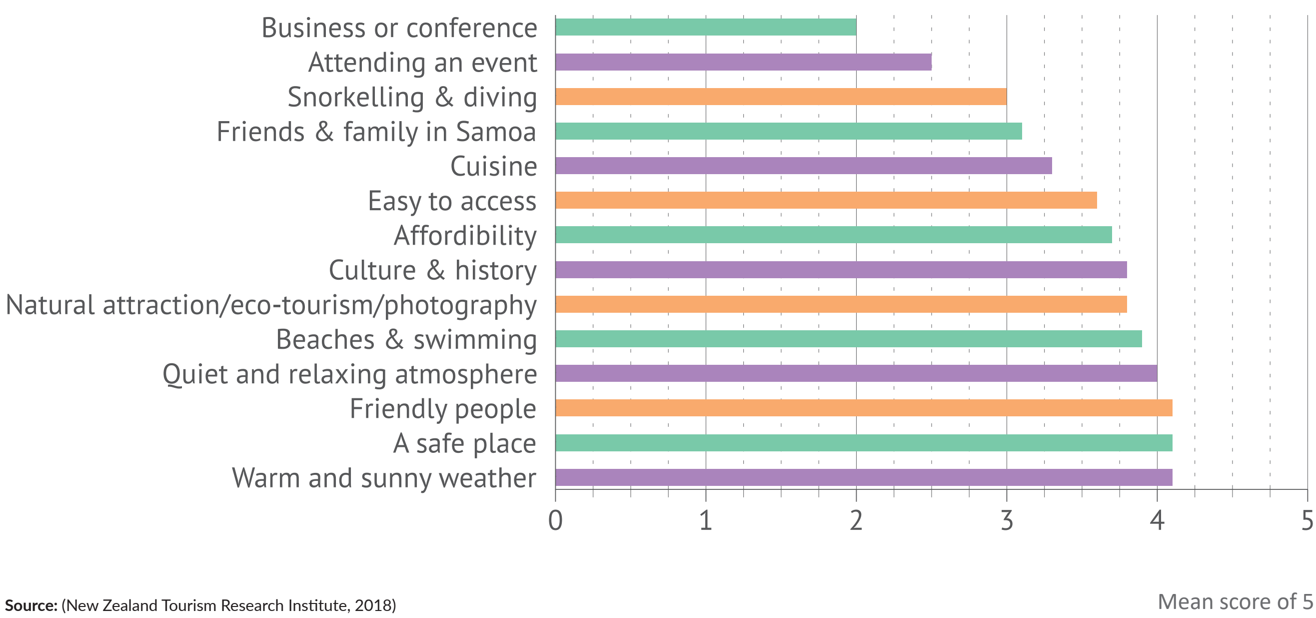
A preliminary online advertisement and image survey of the overnight stay accommodation in Samoa was conducted on the 15th and 16th August 2020 by this report's lead consultant to identify the percentage coverage of marine and coastal ecosystems used to promote tourism. This included pictures of healthy reefs and picturesque seaside environments, snorkeling, diving, surfing and white sandy beaches. A very high percentage of water-based tour operators, deluxe hotels, beachside resorts and villas, and beach fales promoted their businesses through advertisements centered on the coastal and marine environment compared to other types of accommodation, giving an overall average of 49.2% in Table 20.

Table 20: Proportion of images related to marine *ecosystem* attributes in online advertisement

General Category of Accommodation	Percentage (%)
Deluxe hotels, beach seaside resorts and villas	75
Superior standard hotels, villas and apartments	20
Standard hotels, surf beach resort, backpackers	23
Budget type	30
Approved overnight beach fales	98
Overall Average	49.2%

Figure 21 outlines the factors influencing the choice of visits to Samoa identified in the visitor survey report (New Zealand Tourism Research Institute, 2018). These include warm and sunny weather, a relaxing atmosphere, beaches and swimming, a safe place, the culture and history, the natural attractions/eco-tourism/ photography, ease of access, snorkeling,diving and affordability (Milne, *et al.*, 2019). Table 21 provides a summary of the most visited destinations on Upolu and Savai'i which clearly demonstrates that all six places in Upolu are coastal-based, while four of the five places in Savai'i are coastal-based. This is further illustrated in Figure 22.

Figure 22: Factors influencing the choice of visit to Samoa



Source: (New Zealand Tourism Research Institute, 2018)

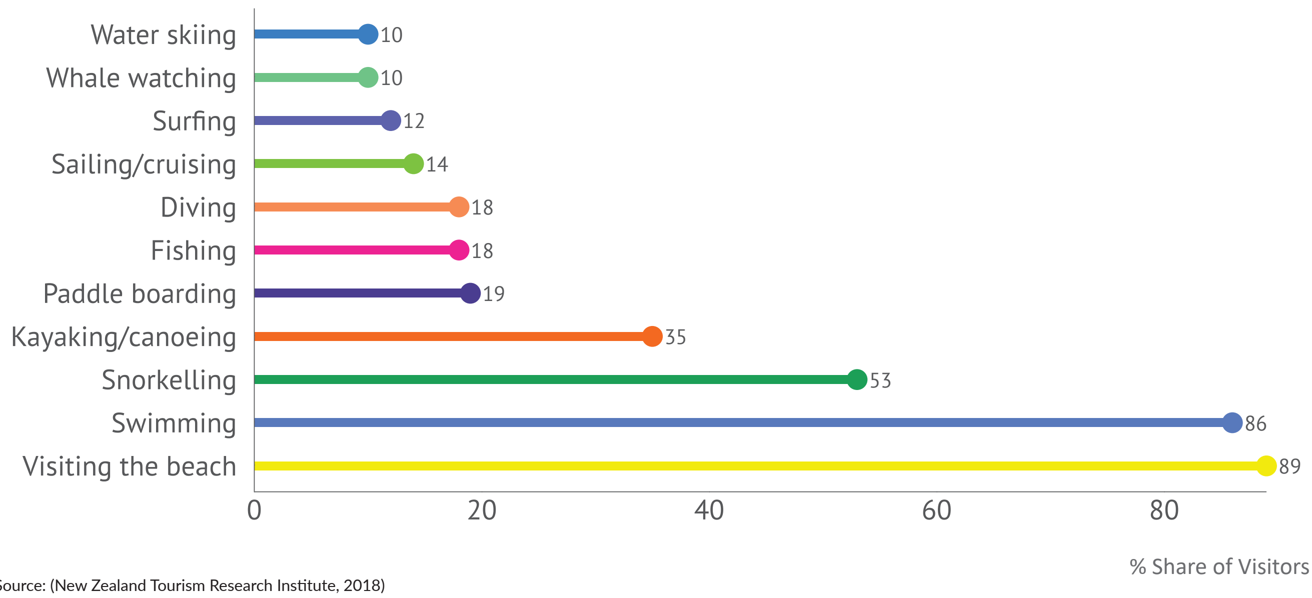
Table 21: Most popular destinations visited in Samoa

Upolu (6 Popular Attractions)	Percentage (%)	**Coastal based**
Apia	66	X
To Sua Ocean Trench	45	X
Piula Cave Pool	33	X
Mulifanua	28	X
Togitogiga Falls	24	X

Savai'i (Top 5 Attractions)		
Salelologa	56	X
Alofaaga Blowholes	46	X
Saleaula Lava Fields	45	X
Afu Aau Waterfall	40	
Swimming with Turtles	39	X

Source: (Milne, *et al.*, 2019).

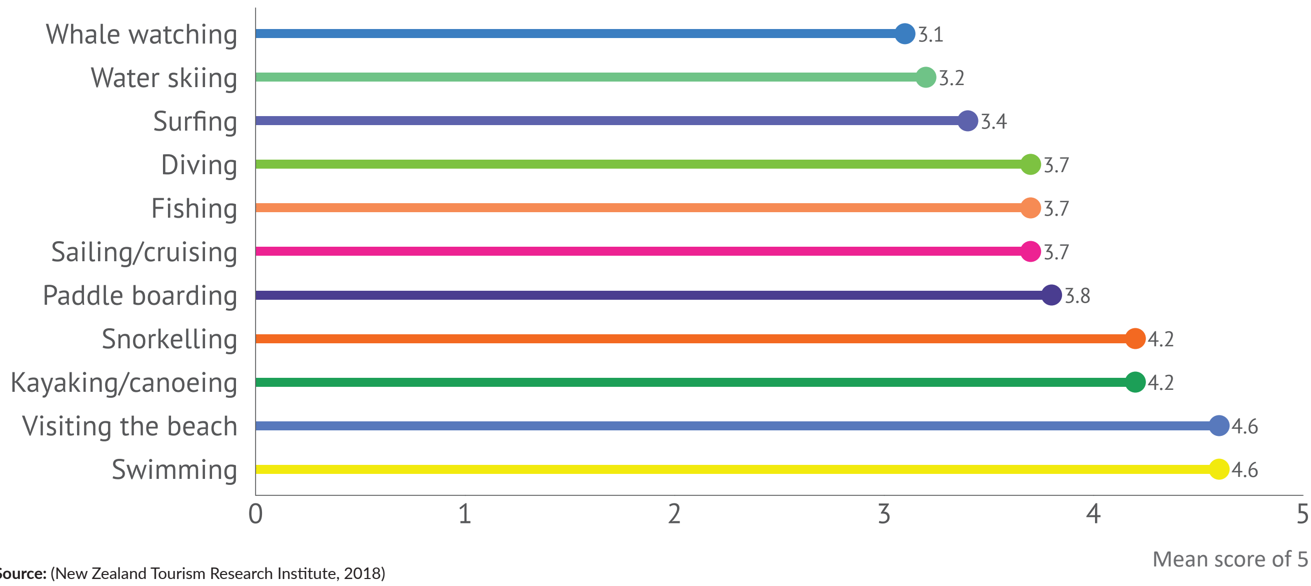
Figure 23: Degree of participation in water-based activities



Source: (New Zealand Tourism Research Institute, 2018)

The international visitor survey report investigated the experience of visitors in water-based activities, and their overall level of satisfaction on a scale of 1 = 'very dissatisfied' to 5 = 'very satisfied' (New Zealand Tourism Research Institute, 2018). Figure 23 shows the percentage of respondents who undertook specific water-based activities during their visit to Samoa. Figure 24 shows that 89% of the respondents visited a beach, 86% went swimming, and 53% undertook snorkeling.In terms of visitor satisfaction, water-based activities had an overall rating of 3.8 (New Zealand Tourism Research Institute, 2018). The survey noted that activities like whale watching (n=239), water skiing (n=245) and surfing (n=298) are characterised by a relatively low number of participants. However, the majority of respondents who visited a beach and went swimming had a relatively high level of satisfaction (4.6). It is evident from this survey that the quality of coastal beaches and coastal waters including reefs and lagoons, has a strong influence on the satisfaction of international tourists to visit Samoa.

Figure 24: Degree of satisfaction in water-based activities



Source: (New Zealand Tourism Research Institute, 2018)

Spalding *et al.* (2017) use global data that includes social media and crowd-sourced datasets to estimate and map two distinct components of reef *values*. Local 'reef adjacent' *values* capture a range of indirect benefits from coral reefs, including provision of sandy beaches, sheltered water, food, and attractive views, while the 'on reef' *value* is directly associated with in-water activities such as diving and snorkeling. Tourism *values* were estimated as a proportion of the total visits and spending by coastal tourists within 30 km of reefs.

The study concluded that some 30% of the world's reefs are of *value* to the tourism sector, with a total *value* estimated at nearly US$36 billion, or over 9% of all coastal tourism *value* in the world's coral reef countries. Samoa was one of the countries included in the study, which estimated the total reef-associated visitor expenditure at US$12.49 million. Reef-associated visitor expenditure was estimated at 9.65% of the total tourism expenditure, and reef tourism at about 1.55% of GDP (Spalding, *et al.*, 2017). The mean *value* of the reef relating to tourism was estimated as US$31,089 km^{-2}.

6.5.1.3 Value

The benefits of a tourism activity to producers (their *profits*) are the service providers' *revenue* from tourist expenditure minus the cost of providing the service. The benefit tourists receive is measured as the difference between what they would be willing to pay for the activities, travel, and accommodation, and what they actually paid. This benefit to tourists is known as the *consumer surplus*[27]. It is difficult to estimate consumer (tourist) benefits without conducting a detailed primary survey of their willingness to pay for tourism-related identified activities and services. Although the benefits largely accrue to foreign individuals, they are significantly important and impacted by the health and beauty of natural ecosystems (Salcone, *et al.*, 2015).

Recreational activities that involve marketed services, such as diving and charter fishing, can be quantified by measuring direct tourist expenditure. Other activities such as swimming, beach picnics and appreciating the coastal environmental aesthetics can be quantified by indirect expenditure (i.e. transportation cost or equipment cost, or *opportunity cost* of time spent participating), or by a willingness to pay through conducting a survey. Both direct and indirect expenditure contribute to the *value* of the *ecosystem* service.

The difficulty in estimating the *value* of tourism associated with an *ecosystem* service to producers and consumers, lies in determining how much of the tourist expenditure

27 For example, if a tourist is willing to pay up to $1000 for a day's fishing charter trip, but he pays only $800 as the cost of the day's charter, the tourist consumer surplus (net benefit) will be $200.

is directly related to natural ecosystems. Reefs, beaches, lagoons, and marine biodiversity including charismatic megafauna, all contribute to the marketability of tourist activities. The degree of association between marine and coastal ecosystems and the different tourist activities is the *ecosystem contribution factor* (ECF). The net producer *value* of the *ecosystem* service is calculated by multiplying the ECF by the difference between tourist expenditure and the tourism industry's costs.

Producer surplus $_{(\$)}$ *= (Total Tourism Revenue*$_{\$}$ *- Tourism Industry Costs*$_{\$}$*) x ECF*

Where an *ecosystem* is the sole factor contributing to a tourist decision (such as for snorkeling on a healthy reef and clear crystal waters) an ECF of 100% (= 1) would represent the maximum. Less direct use such as swimming, beach accommodation and relaxation, is determined by an estimate of how much the environmental attributes contribute to the tourist decisions and expectations.

Data on direct marine-related activities are used to estimate the ECF for ecosystems, such as reefs and beaches, that provide the *ecosystem services* in question. If the mean scores of 3 out of 5 for snorkeling and diving and 3.9 out of 5 for beaches and swimming from Figure 23 is converted to a percentage average of these activities, the result is an ECF of 78% for beaches and swimming, and an ECF of 60% for snorkeling and diving. In addition, all accommodation advertisements online in Samoa were surveyed for inclusion of images in the form of healthy reefs, recreational fishing, snorkeling, diving, picturesque and white sandy beaches. The mean score from the images gave an ECF of 49% which is the minimum *value* assigned to coastal and marine ecosystems. Using the *values* derived from the international visitor survey of 60% as a minimum *value* assigned to snorkeling and diving, and a maximum *value* of 78% for beaches and swimming, the estimated gross tourism expenditure attributed to these *ecosystem services* is shown in Table 22.

Table 22: Gross tourism expenditure and net tourism benefit from marine and coastal ecosystems

Gross expenditure SAT$ (million)		**Marine and coastal ecosystems contribution factor**		***Value* added**	**Net benefit** SAT$ (million)	
Min	**Max**	**Min**	**Max**		**Min**	**Max**
182.47[a]	447.27[b]	60%	78%	44.5% [c]	48.72	155.25

a. On average, 35.5% of tourists listed participating in snorkeling and diving. 35.5% of International Tourist Expenditure of SAT$514.1 million is SAT$182.47 million.

b. On average, 87% of tourists listed participating in beach recreation and swimming. 87% of SAT$514.1 million is SAT$447.

c. Intermediate cost of 55.5% from IVS (2013).

On average, 35.5% of the international tourists participated in snorkeling and diving, while the average participation for beaches and swimming was 87%. Given that costs vary across the different industries and data on costs are not readily available, the estimated intermediate cost from the 2013 international visitor survey was used to estimate a *value added* of 44.5% to derive the net producer benefit of gross tourism *revenue*. Table 21 shows the net producer benefit from coastal and marine ecosystems generated annually SAT$ 48.72 – SAT$155.25 million.

The government of Samoa benefits from marine and coastal tourism through tax *revenue*. The *value*- added goods and services tax (VAGST) in Samoa is 15%. Tourists pay 15% on most purchases including hotels and restaurants. Based on the gross expenditure attributed to marine and coastal ecosystems (SAT$182.47 – SAT$447.27 million), the government of Samoa could receive about (SAT$27.37-SAT$67.09 million) in tax *revenue* from this *ecosystem* service. The *total economic value* of an *ecosystem* service is the sum of the producer and consumer benefits and government benefits. The producer benefit and government benefits are estimated at SAT$76.09 – SAT$222.34 million. The benefits that tourists receive from marine and coastal ecosystems have not been quantified in this study. Estimating consumer benefits would require a detailed survey of tourists' behavior and preferences.

6.5.1.4 Uncertainty

Table 22 summarises the information available on international tourism in Samoa. There are several sources of uncertainty in the estimates. Each tourist site has different environmental attributes that influence producer earnings and tourist benefits, such as the variety of fish seen while snorkeling or the quality of water for swimming. Tourist benefits are also influenced by infrastructure, amenities, and proximity to transportation. To determine the effect specific to environmental attributes on tourism demand, models must control for non-environmental factors, and be able to rank environmental amenities (Salcone, *et al.*, 2015).

Uncertainty exists regarding the estimates of the *ecosystem contribution factor*. Data is extracted from the international visitor survey and used as a proxy to estimate the ECF because tourists respond with multiple reasons for their visit to Samoa, thus it is difficult to prioritise their preferences. Aggregation of data also reduces the variety of responses. Providing a range for the ECF (60–78%) can better show that the true *value* lies within these minimum and maximum estimates. The *value added* ratio (44.5%) is based on the international visitor survey report. Some businesses may earn more *profits*, others may have *profits* lower than 40%. As with most of the *ecosystem services* in this study, we presume that estimates of producer and government benefits are below the total social benefit of the *ecosystem* service because they do not include the consumer benefits. Producer and government benefits may be most relevant however, because they accrue in Samoa, whereas consumer benefits accrue to foreigners.

6.5.1.5 Sustainability

If managed responsibly, tourism can be a lucrative and sustainable activity supported by coastal ecosystems. Tourists are often motivated by the desire to protect healthy ecosystems. This motivation can provide an incentive to support the protection and even rehabilitation of marine environments. The ecological impact of snorkeling, diving, swimming, and beach walking can be minimal if activities are carefully managed, and tourists are aware of their potential impact on these environments. However, tourism can also increase demand for water, energy, infrastructure, food and imported goods. It can generate harmful waste and pollution as well as exacerbate coastal urbanisation. If poorly managed, these impacts can lead to degradation of the ecosystems the tourists are originally attracted to. The Samoan authorities must carefully *evaluate* the environmental pressures of tourism and focus on what can be achieved realistically and practically, and how the *economic benefits* can be sustained, given the critical role of tourism in the economy.

A number of natural and unique attractions in Samoa can further draw tourists, such as the Palolo Deep Marine Reserve, Safata Marine Protected Area, swimming with turtles, seasonal whale watching, dolphin watching, recreational fishing for billfishes, white sandy beaches and experiencing '*fale*' type beach accommodation for relaxation. A better insight into cultural *values* and Samoan diaspora tourism is needed to ascertain the *value* of this aspect of *ecosystem services*.

Ongoing programmes in the six districts will need continuous support to provide a holistic development platform for tourism in Samoa. Local opportunities and climate adaptation measures can reduce vulnerability to natural disasters which impact life and properties in coastal areas. In addition, implementing the National Waste Management Strategy (2019 -2023) and Samoa's National Action Programme to Combat Land Degradation and Mitigation of Effects of Drought (2015- 2020), can help reduce waste and control land-based pollution, which are primary causes of coastal and marine pollution. Effective implementation and enforcement of the Fisheries Act and the Fisheries Management Act, and protection of biodiversity are all essential to achieve sustainable tourism.

6.5.1.6 Distribution

The benefits of tourism are split between government (tax *revenues*), business owners, employees, and the tourists themselves. Producer *profit* (for local businesses) and government *revenue* are benefits received within Samoa. Factors determining net *economic benefits* include the local share of goods and services purchased by tourists, the linkages between tourism sectors and their supply chain, the labour and capital intensities of these sectors, and local and foreign ownership of the tourism operations (Hampton, *et al.*, 2018).

Some tourism businesses are foreign-owned, whereby a portion of their *profits* will be re-invested in Samoa, while some will be invested outside the country. Similarly, some tourist expenditure accrues abroad, while some returns to Samoa to pay for services. For example, the International Visitor Survey (2018) estimated that about 55% of the average tourist spend flows back to Samoa. Backward and forward linkages[28] are generated where local communities become suppliers of tourist products (accommodation, food, transport, tour guides). This can expand the local supply chain and further stimulate innovation and new tourism businesses.

Employee wages are a cost to tourism businesses, but a benefit to Samoan households. International tourism *revenue* is cash flowing into Samoa from overseas. Like exports, international tourism generates positive foreign exchange.

6.5.2 Domestic recreation and tourism

When domestic tourists participate in market-based activities such as joining commercial dive trips, game fishing, staying in hotels and eating in restaurants, the domestic recreation and tourism related to coastal ecosystems is much the same as for international tourism. However, tourism or recreational activities that do not involve fees or direct costs also have *economic value*, although different methods must be used to quantify and *value* these activities (Salcone, *et al.*, 2015). Domestic tourism can be a powerful tool to generate employment and economic growth, raise environmental awareness, and support social health and infrastructure development.

6.5.2.1 Identify

As in the case of international tourism, domestic recreation and tourism depends on two things: the availability and quality of natural attractions and infrastructure and service investments, such as transportation systems, beach and boat access areas and businesses that facilitate use and appreciation of natural environments. Although residents may participate in different activities and hold different *values* from international tourists, some of their leisure and recreation activities, such as swimming or reef-walking, are dependent on the quality of marine and coastal ecosystems.

Beach *fales* are a unique feature and an increasingly popular aspect of the Samoan coastal landscape. Other marine related activities such as fishing, diving, snorkeling, jet skiing and surfing are also associated with this type of accommodation. Non-marketed activities such as beach walking, enjoying fresh air, sunsets and the aesthetics of the coastal environment can be characterised as public goods.[29] Therefore, although the per capita benefits may be small in magnitude, the total social benefit to all Samoans could be large.

6.5.2.2 Quantify

The *value* of coastal and marine *ecosystem services* can be measured by ranking the preferences of local Samoans for different natural areas and attractions, and then quantifying them. Surveys, for example, could collect data on the number of individuals participating in marine and coastal-based activities such as swimming, snorkeling, surfing, diving, recreational fishing or relaxing on the beach. Additional data could include details about how often, and when, individuals participate in these activities, their order of preference, kinds of costs incurred, what individuals are willing to pay or trade and what are their *opportunity costs* from engaging in the various activities.

A survey on domestic tourism expenditure conducted by the Samoan Tourism Authority in 2013, focused on the marketed aspect of domestic tourism.[30] The study looked at travel between Upolu and Savai'i, and estimated that the average length of stay was 4.41 nights with an average expenditure of SAT$60 per night (2014 prices). The total number of overnight trips was estimated to be 84,000, with visitors staying for some 370,000 nights, and spending an estimated SAT$22 million (2014 prices). The study further estimated that nearly half of this expenditure was associated with Fa'alavelave (Samoa Tourism Authority, 2015). Other major parts of expenditure were food, transport, and accommodation, while 7.5% of the expenditure was categorized as 'other'. It is assumed that a portion of this could have been spent as fees and charges for water-based activities.

Domestic and diaspora tourism in Samoa has been investigated using a case study of beach *fale* accommodation (Scheyvens, 2007). The day tripper paid around SAT$80 for a bus, SAT$30 for a van and SAT15 for a car (2007 prices). This expenditure included access to the beach and bathrooms. The study noted that for overnight *fale* accommodation with light, bedding and shared bathrooms,

28 Forward linkages measure the relative importance of each sector as a supplier to other sectors in the economy, whereas backward linkages measure the relative importance of each sector as a user of goods and services from other sectors.

29 Public goods are non-rival activities whereby an individual's benefit does not impinge on another's benefit.

30 Domestic tourism was defined as 'travel outside of the usual environment'. This included individuals who visited the other main islands of Upolu and Savai'i and vice versa for overnight trips and visits within one's own island staying in commercial (paid) accommodation for the night. (Samoa Tourism Authority, 2015)

the cost was around SAT$50 - $60 per night. The cur*rent* prices for similar accommodation range between SAT$80 - SAT$130 per night, while transport costs are between SAT$100 - $300 (Tripadvisor.com accessed 21 August 2020).

6.5.2.3 Value

An estimation of consumer benefits from non-market recreational activities by residents would require the use of *stated preference survey method*s which is beyond the scope of the current study. Costs associated with domestic recreation and tourism include public infrastructure development, transportation costs for those participating, and negative externalities such as solid waste pollution from visitation. These costs would need to be subtracted from the total *economic benefit*s or the willingness to pay to determine the true *economic value*.

The tourism impact analysis survey completed in 2013 by the Tourism Authority, estimated the *value* of domestic tourism around SAT$22 million (Samoa Tourism Authority, 2015). Adjusting population and *inflation* to 2019 figures, this is likely to be around SAT$29.7 million. This estimate does not include local visitors to beach *fale* for weekends and holidays, which is a growing part of Samoan domestic tourism. Tourist expenditure on accommodation, food and other water-based activities can be estimated through case studies of service provider records or through surveys of participating tourists. Although information on certain costs is available such as entrance fees, accommodation rates, wages and travel costs, a more comprehensive assessment of the range of costs and benefits (monetary and non-monetary services) is required to capture the *real* impact of domestic tourism and recreation on the economy.

6.5.2.4 Uncertainty

Although domestic recreational tourism related to marine and coastal ecosystems has a high *value* for Samoans, huge data gaps remain which prevent accurate estimation of its *real economic value*. For example, the estimate of travel between Upolu and Savai'i only reflects one aspect of the domestic tourism in Samoa. The *value* of domestic recreation and tourism should be *evaluate*d and included in marine and coastal resource management and planning.

6.5.2.5 Sustainability

As with international tourism, increased pollution and waste from visitors can have harmful impacts on marine and coastal areas. Environmental awareness programs, provision of litter bins and waste management etiquette measures are necessary to minimise such threats.

Domestic recreation and tourism combined with diaspora tourism have a strong social and cultural dimension for Samoans, especially in relation to the preservation of coastal and marine areas. For example, marine fauna features prominently in the cultural folklore and oral tradition of Samoa. Many traditional proverbs and expressions are associated with traditional methods of fishing and hunting and human interaction with the natural environment (Ministry of Natural Resources and Environment, 2015). Thus, long-term societal *value*s may outweigh the short-term costs associated with providing infrastructure and facilities to support tourism activities.

6.5.2.6 Distribution

Most of the benefits from domestic recreation and tourism accrue to local Samoans. Although some associated expenditures may create benefits for import industries or foreign-owned businesses, most benefits are received by the individuals participating in marine and coastal recreation and leisure activities. These activities may generate broader benefits to society by supporting the health and happiness of individuals, and they may generate support for government infrastructure investment and nature conservation.

6.6 Coastal protection

Flooding, erosion, inundation and extreme weather events affect local communities, infrastructure, tourism, trade, and cause significant human suffering and loss to national economies. For example, in 2012 Cyclone Evan caused immense damage and significant losses in Samoa. The *value* of durable physical assets across all sectors destroyed by Evan was estimated at SAT $235.7 million, equivalent to US$103.30 million (Government of Samoa, 2013 b). In addition, production losses and higher production costs arising from the disaster were estimated at SAT $229.4 million or US$ 100.6 million, with the total effects of the disaster amounting to SAT$ 465 million or US$ 203.9 million (Government of Samoa, 2013 b). Insurers pay billions of dollars for coastal damages from storms which often go towards rebuilding infrastructure that remains highly vulnerable to coastal storms and flooding (World Bank, 2016).

Coastal and marine habitats can substantially reduce the exposure and vulnerability of coastal communities to climate change and coastal hazards by providing natural protection from risks. For example, intertidal wetlands and reefs can play a critical role in reducing vulnerability through their multiple roles in wave attenuation, sediment capture, vertical accretion, erosion reduction and mitigation of storm surge and debris movement (Spalding, *et al.*, 2014).

Coral reefs protect coasts from erosion and flooding by absorbing wave energy, as well as supplying and trapping sediment found on adjacent beaches. Besides functioning as breakwaters, coral reefs are able to generate massive amounts of carbonate structures and are generally expected to keep pace with sea level (Kramer, 2016). Unlike artificial breakwaters that require significant maintenance expenditure, coral reefs are self-sustaining as long as they remain healthy. A reef's cross-shore bathymetric profile, the height and width of the barrier, and surface rugosity are important variables influencing the degree of wave attenuation (World Bank, 2016).

Mangrove forests also reduce risk from coastal hazards such as waves, storm surges[31] and tsunamis. They reduce flood depth and wave height, lessening damage to properties behind the forests. The level of risk reduction depends on the type of hazard, as well as the characteristics of the mangroves. The height of wind and swell waves can be reduced by 50 % to 100 % over 500 m of mangrove forests (McIvor, et al, 2016). Mangrove species with dense vegetation are more effective at reducing wave height. With respect to storm surges, water level measurements show that a one kilometre-wide mangrove forest can reduce storm peak water levels by 5 cm to 50 cm (McIvor, *et al.*, 2016).

In addition, sufficient evidence exists about the capacity of submerged aquatic vegetation, such as seagrass, to physically and chemically engineer their environment and to supply coastal protection services (Christianen, *et al.*, 2013). From a physical perspective, seagrasses are able to influence the hydrodynamic environment by reducing current velocity, dissipating wave energy and stabilising sediments. The role of seagrasses in providing coastal defence services depends on their capacity to attenuate the processes of flooding and coastal erosion. For example, the efficiency of protection depends largely on the incident energy flux by tides, storm surge, waves and currents, and the density of standing biomass and plant stiffness (Ondiviela, *et al.*, 2014).

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

Samoa is exposed to a number of natural hazards, including tropical cyclones, earthquakes, tsunami, volcanic eruptions and drought (Government of Samoa, 2013 b). Samoa's vulnerability is partly due to its geographic location south of the equator in an area known for its frequent tropical cyclones and damaging winds, rain and storm surges between October and May (Ministry of Natural Resources and Environment, 2013).

6.6.1 Identify

Coastal protection is a concept that includes the different roles an ecosystem plays in protecting coastal areas; long-term protection against the removal and deposition of sediments through erosion and accretion; and short-term protection against coastal floods and storm surges. The short-term protection happens episodically, and the damage avoided is clearly identifiable (damaged buildings, roads, crops), while the effects of long-term problems are more diffuse over time (Pascal, *et al.*, 2015).

Reefs are known to assist beach formation, which occurs with the accumulation of sediments from various origins (marine and alluvial). Coastlines near coral reefs receive sediments from these reefs in the form of small dead coral particles. Accumulation of these sediments along the coastline contributes to beach formation. Sedimentary accretion also maintains and nourishes beaches, as opposed to natural or anthropogenic erosion (Pascal, *et al.*, 2015).

The scope of this study is to identify all ecosystem services at a national scale, and where possible, quantify and value those with readily available data. The assessment of erosion prevention and provisioning of sediment is a data-demanding exercise, and therefore it is not possible to accurately quantify ecosystem service protection against erosion, even though some natural processes of erosion protection are well described. Nevertheless, it is still difficult to quantify and estimate the economic value of these services.

The sedimentation process in Apia, and along the coastal areas of Upolu and Savai'i, are important for policies relating to residential and tourism infrastructure development. Various reports are available that illuminate aspects of shoreline stabilization and beach formation (see Fepulea'i & Fepulea'i, 2017; Nairn, *et al.*, 2017; Siamomua-Momoemausu, 2013 b; Sai Faleupolu, 2015).

The present report focuses on the value of storm surge mitigation by coral reefs, which is one of the most important aspects of coastal protection provided by marine ecosystems (World Bank, 2016; Paeniu, et al 2015). Storm systems, such as tropical cyclones, are the primary causes of storm surges which interact with other ocean processes, such as tides and waves, to further increase coastal sea levels and flooding. Storm surges occurring at higher mean sea levels cause inundation and damaging waves to penetrate further inland, which increases flooding, erosion and damage to built infrastructure and natural ecosystems. The effect of rising mean sea levels due to climate change will be felt most profoundly during tsunamis or extreme storm conditions (Pascal, *et al.*, 2015).

Coral reefs and mangroves act as a protective barrier on the swell of the ocean, resulting in a transformation of wave characteristics and a rapid attenuation of wave energy. The primary factors influencing attenuation of wave energy are:

I. Bathymetry (shape and depth of sea or ocean floor);

II. Geomorphology (soil origin, size and composition);

III. Topography (coastal and inland surface shape and shoreline indentations); and

IV. Biological cover (presence of other ecosystems in the coastal area) (Burke, 2004; Pascal, *et al.*, 2015).

The ability of different habitats to provide coastal protective services varies as a function of the above factors (Burke, 2004; Pascal, *et al.*, 2015). Few studies have focused on isolating the specific role of coral reefs within the above combination of factors (Badola & Hussain, 2005). In addition to the complexity of quantifying the specific contribution to coastal protection, an analysis by Barbier *et al.* found that the relationship between reef area and absorption of wave energy, and the effect of mangroves on wave height was nonlinear (Barbier, *et al.*, 2008). Furthermore, a study by Guannel *et al.* shows that together with the coral reefs, seagrass and mangroves supply more protection services than any individual habitat or any combination of two habitats (Guannel, *et al.*, 2016).

The study demonstrates the importance of applying an integrated and place-based approach when quantifying and managing coastal protection services supplied by ecosystems. Using only a single habitat only for the protection of coastal regions against specific forcing conditions, treats natural systems as alternatives to traditional mono-functional hard coastal structures, thereby under-utilising the potential of all the habitats present on the entire seascape.

Around 70% of the Samoans live within one kilometre of the coastline (World Bank, 2013). Samoa is ranked 30th of the countries most exposed to three or more hazards (Government of Samoa, 2013 b, p. 1). The urban areas of Apia suffer greatly from the effects of flooding. Flood waters and floating debris can cause structural damage to businesses, homes and other infrastructure, such as roads and bridges. Tropical storms and cyclones are the main hazards for Samoa, accompanied by damaging winds, rainfall, swells and storm surges. The higher the floodwater, the greater the pressure on walls and floors, and the greater the damage and repair costs. Significant flooding results in If , homes and structures, such as fales, completely destroyed or swept away by flood waters (Woodruff, 2008).

The worst cyclones to have impacted Samoa in recent times are Ofa in 1990, Val in 1991 and Evan in 2012. A report by the government of Samoa on post-disaster needs assessment after cyclone Evan evaluates the loss and damages caused by the cyclone. A climate risk profile on Samoa can be found in various publications (see Young, 2007; Woodruff, 2008; Government of Samoa, 2013 b; World Bank, 2013 b; Applied Geoscience and Technology Division (SOPAC) SPC, 2011; World Bank, 2015) and at the Pacific Climate Risk Assessment Financing Initiative (PCRAFI) website: pcrafi.spc.int.

6.6.2 Quantify

The value of ecosystem services for coastal protection is the avoided damage cost, or the cost of replacing the natural ecosystems with man-made equivalents. A study in 2000 estimated the coastal protection services by mangrove forests in Samoa by considering the expenditure avoided with the construction of sea walls along the 25.7 km of coastline as SAT$6,425,000. The capitalized value of this ecological function gave an annual benefit of SAT$ 277,242 or the cost avoided due to the presence of coastal ecosystems (Mohd-Shahwahid, 2001). Using both replacement cost and benefit transfer, Ram-Bidesi *et al.* estimated the value of coastal protection provided by 28.43 km of coastal mangroves in Safata District to range between SAT$2.3 million or US$0.92 million, to SAT$ 56.86 million or US$22.74 million (Ram-Bidesi, *et al.*, 2014). The damages avoided by having mangroves were estimated at SAT$2.3 million, while the cost of building a sea wall around SAT$ 56.86 million if mangroves were destroyed. Figure 25 shows the mangroves acting as a protective barrier.

Figure 25: Mangroves act as a protective barrier for coastal areas

The *avoided damage costs* method considers different types of avoided costs, such as cost of property damage likely to occur in the absence of the ecosystems in question. The damage costs method requires (1) determination of the extent of protection provided by natural ecosystems, (2) the population, property and human infrastructure at risk from erosion or flood damage, and (3) the probability of damages given the estimated frequency of flood or erosion events. The *value* of the natural ecosystems is the costs from expected damages to homes, businesses, agriculture, or public infrastructure avoided because of the presence of natural ecosystems. The *avoided damage cost* method has been used to *value* coastal protection *ecosystem services* of the Caribbean Islands (Burke, 2004) and by the MACBIO *ecosystem* assessment and *valuation* studies in Vanuatu, the Solomon Islands and Fiji (Pascal, *et al.*, 2015; Salcone, *et al.*, 2015; Gonzalez, *et al.*, 2015). This study adopts the same methodology (avoided cost) to estimate the expected annual damage due to coastal flooding.

Coastal protection index

Coastal stability is based on seven physical characteristics, as outlined in Table 23. These physical characteristics were given a score between 1 and 5, and the calculated average produced a unique index *value* for each segment of the shoreline i.e. the Coastal Protection Index. The specific contribution of mangroves and seagrass are not monetised but integrated into the coastal protection index as one of the main factors contributing to coastal protection.

Table 23: Characteristics of the coastline included in the coastal protection index (CPI)

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

Source: (Salcone, *et al.*, 2016; Pascal, *et al.*, 2015)

Two main GIS databases were used for data related to reefs (type of reefs, area and distance to the coast) i.e. PCRAFI and Reefbase (Pascal, *et al.*, 2015). Figure 26 shows the map of reefs in Samoa. To derive data on coastal stability, Samoa was divided into 43 districts with relatively more homogeneous morphology of reef and exposure to waves, then aggregated into four regions for analysis. The seven characteristics for the four regions are briefly explained below:

Geomorphology: The Samoan Islands are generally a mix of sedimentary rocks, soil and beaches. The score is low for urban Apia, while for Savai'i and the rest of Upolu, it is high due to the high elevation of the shoreline of northeast Upolu and northern and southern Savai'i. The coasts around north Savai'i comprise high cliff and rocky outcrops, while the Palauli le Falefa district is characterized by steep basalt cliffs and lava rocks. The reef system is 1 to 2 km off the shoreline in the Faleata Sisifo district of Apia, with some siltation and sediments due to reclaimed land near the Vaiusu Bay.

Coastal exposure: Faleata East and Apia Harbour in Urban Apia provide some shelter with high levels of protection, while the rest of Upolu has a medium level of exposure, although Safata and Vaa o Fonoti have a high score of 5. The northwest Upolu region has low protection due to a uniform coastline exposure that lacks any remarkable shoreline structure to protect coastal assets, while Savai'i has a medium score of 3.

Reef morphology, area and distance to the coast: The fringing and barrier reefs are more developed in Upolu than on Savai'i. The northwestern shoreline is characterized by a narrow fringing reef, while the south coast has coral formation and lagoon. Scores are high for Upolu and medium for Savai'i.

Inner slope, crest width: There is a gentle slope and large crest width for some parts of Apia and northwest of Upolu, particularly in the Sagaga le Falefa area. The rest of Upolu has a medium score, except for areas such as Lepa, Lotofaga and Falealili, where it is low.

Platform slope: The deep ocean is near the shoreline creating a platform with a steep slope. The score for Savai'i, is high in areas like Vaisigano West and Palauli, while it is low for Apia, and medium for northwest Upolu and the rest of Uplou.

Mean Depth (1 km from the shoreline): As the deep ocean is near the shoreline, the main depth is greater than 30 m and less than 1 km from the coast. Apart from Apia, the rest of the Samoan coastline has a mean depth greater than 5m, with a medium score of 3.

Other ecosystems: Mangroves and seagrasses along the shoreline were considered. Savai'i had an overall low score of 2, indicating the limited presence of these ecosystems. Mangroves are found in Upolu in the Vaiusu Bay and across the south coast in the Safata district. Seagrass beds are present around the Manono Island and northern parts of Upolu, giving an overall score for Apia of 4, and 3 for northwest Upolu. The scores for the four regions of Samoa are summarised in Table 24 .

Figure 26: Reefs of Samoa

Source: https://user.iiasa.ac.at/~marek/fbook/04/geos/ws.html (9 September 2020)

Table 24: Coastal protection index for the 4 regions of Samoa[32]

Factor	Apia urban area	Northwest Upolu	Rest of Upolu	Savai'i
Geomorphology	2	3	4	4
Coastal exposure	5	2	3	3
Reef morphology	5	4	4	3
Inner slope, crest width	5	4	3	3
Platform slope	2	3	3	4
Mean depth	4	3	3	3
Other ecosystems	4	3	3	2
Sum of factor scores	27	22	23	22
CPI	**0.77**	**0.63**	**0.66**	**0.63**

32 Data compiled by John Kaitu'u, GIS Officer, IUCN Oceania using the Reefbase and PCRAFI database

Main notable assets at risk

The number, type and location of residential buildings and hotels at risk from coastal flooding and storm surge were assessed. These are areas that have a lower elevation than the maximum wave height at high tide and are up to 1 km inland. Disaggregated data was not available to distinguish public buildings and infrastructure such as roads, bridges and crops specifically vulnerable to coastal flooding.

Apia, the capital of Samoa, is located on the northern part of Upolu where 19% of Samoa's total population resides.

An estimated 70% of the Samoan population live within one kilometre of the coast - of the total current population of 198,000, almost 138,600 people are living in proximity to the coast.

Approximately 148 hotels and resorts are registered with the Samoan Tourism Authority, ranging from deluxe accommodation to day-visit *fales*. Of these, 126 are located in the coastal area. Table 25 shows the distribution of various types of accommodation in the coastal areas of the 4 regions.

Table 25: Types of tourist accommodation along the coastal areas of Samoa

Type of Accommodation	Apia urban area	Rest of Upolu	Northwest Upolu	Savai'i
Deluxe	3	6	2	2
Standard Superior	6	2	0	2
Standard	14	3	3	6
Budget	18	13	4	2
Holiday home	2	0	0	0
Beach fales (overnight)	0	12	0	10
Beach fales (day visit)	0	16	0	0
Total	**43**	**52**	**9**	**22**

Source: Extracted from STA database (2020)

The presence of the majority of the population and many industrial and commercial activities near the coastal area suggests that a large proportion of the country's industries and infrastructure are at risk from, or susceptible to, storm surge and flooding. Two notable reports focusing on recovery and rehabilitation provide insight into the extent of *real* damages and loss (Government of Samoa, 2013b and Government of Samoa, 2009). As this data is aggregated, it is not possible to identify the level of risk, or protection services attributable to coastal ecosystems services. Consequently it has not been possible to quantify these services.

6.6.3 Value

In general, flooding potentially impacts people, buildings, transport,communications, infrastructure, vehicles, livestock and crops (Salcone, et al 2016). The *avoided damage cost* method is used to *value* the service of protection provided by coral reefs against storm damage. Firstly, the assets protected by reefs are identified and their *value* assessed. In the absence of disaggregated data, the Post-disaster Needs Assessment report produced by the Government of Samoa (2013 b) after Cyclone Evan was used to identify houses and tourist accommodation totally destroyed, partially damaged or had received minor damage.

A risk profile study for Samoa was conducted by SPOAC/SPC in 2010, which provided estimates of overall national costs. Table 26provides an inventory of buildings, infrastructure and main crops at risk, and the corresponding *value*. The replacement *value* of all assets in Samoa was estimated at US $2.6 billion (Government of Samoa, 2013 b).

Table 26: Summary of asset risk profile for Samoa (2010)

Asset Counts	Number	Cost of replacing assets	Million (US$)
Residential buildings	41,960	Buildings	2,148
Public buildings	1,720	Infrastructure	465
Commercial, industrial & other buildings	5,151	Crops	25
All buildings	48,831		
Hectares of main crops	35,553	TOTAL	2,638

Source: (Applied Geoscience and Technology Division (SOPAC)/SPC, 2011)

The replacement costs per building in rural and urban areas were taken from the PCRAFI Report for Samoa, which remains the most exhaustive study on the methodology for risk assessment for Samoa and other Pacific Islands (PCRAFI 2015). These costs were converted to 2019 prices. Minimum and maximum *values* were used to adjust for variation in time periods, as well as variation in cost estimates, with lower *values* assessed at 0.75 of the cost, and higher *values* at 1.25 of the indicative cost.

Figure 27 shows the location of residential areas in Samoa. The median price for construction of a house in Samoa in the urban area was estimated to be US$53,775, while a house in a rural area was US$5,637. The damage cost to a house is assumed to be a fixed 65% of the construction cost if flooding occurs.

Using data from SOPAC studies, the probability of an extreme climatic event is estimated to be 0.4, based on historical storm assessment data. Tropical cyclones have about a 40% chance of being exceeded at least once in 50 years in the next 50 years, with a 100 year mean return period (Applied Geoscience and Technology Division (SOPAC) SPC, 2011).

The expected annual *value* of damage due to coastal flooding is given by the following equation:

$$D_t = P_t * (1 - CPI) * (A * C*DF)$$

D_t = expected flood damage in year t

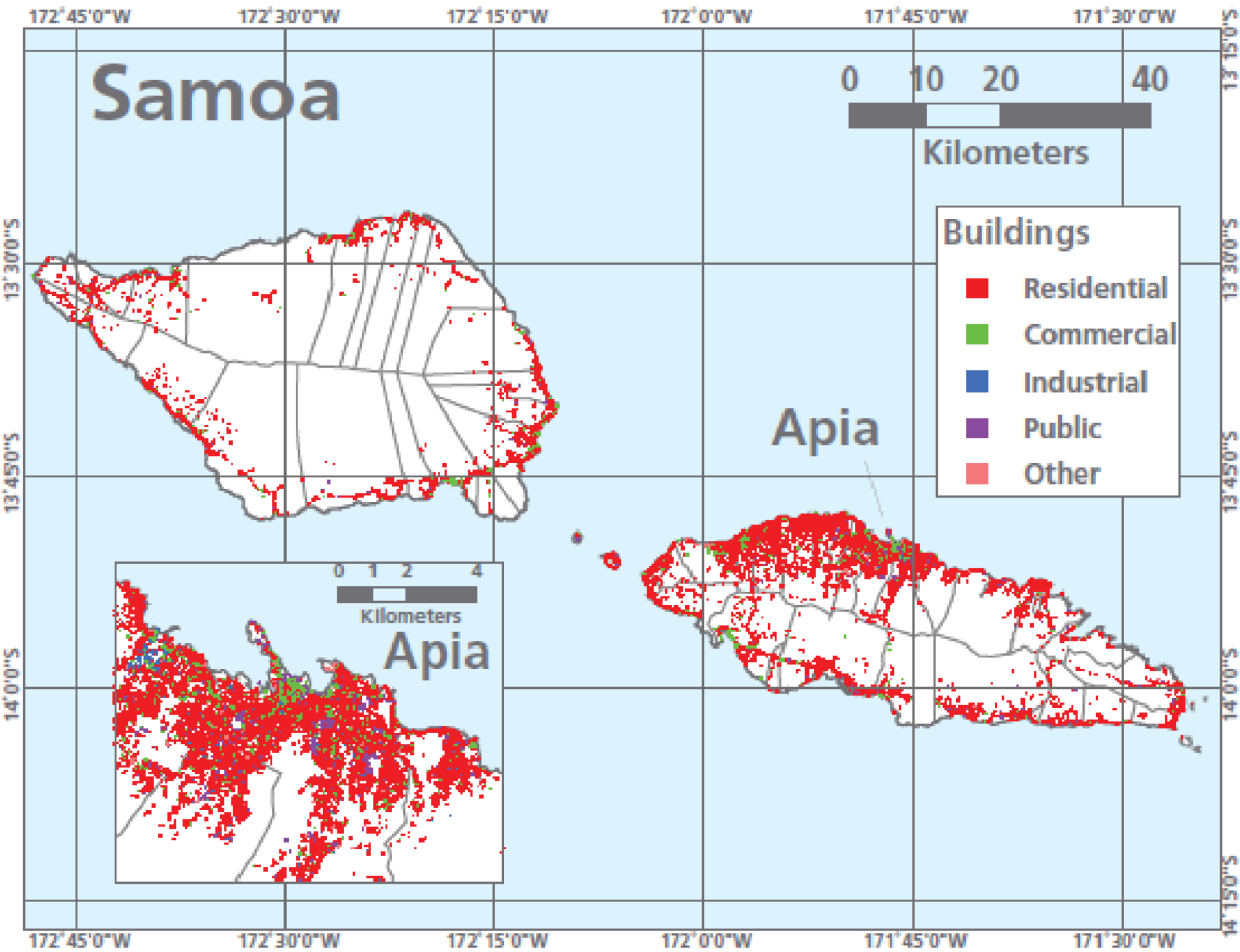
CPI = coastal protection index

C = construction cost (e.g. cost per house)

P_t = probability of storm surge in year t

DF = damage factor (flood damage as a % of construction cost)

Figure 27: Map of residential areas in Samoa



Source: (PCRAFI, 2015)

The total *value* of destroyed assets in the tourism sector was estimated at about SAT$26.7 million (Government of Samoa, 2013 b). Disaggregated and detailed data on the floor spaces of various types of coastal tourist hotels were not available. Therefore, the second option was to use the average replacement cost of non-residential buildings in urban and rural areas in Samoa, based on World Bank estimates (2013). This assessment was cross-checked against the costs of repairing damage to tourist infrastructure following Cyclone Evan (see Appendix 15.2. for details). Benefit Transfer can often be used in the absence of specific data; however, this method was not appropriate in the case of Samoa's unique tourist accommodation types.

Tables 27-30 show the total costs of avoided damage, and annual avoided damage, to human assets at risk associated with the presence of reefs, for the four tourism regions.

Table 27: Cost of damage avoided due to the presence of coral reefs, Apia urban area

Coastal Protection Index 0.77	Number		Unit	Currency	Total value of avoided damages		Annual value of avoided damages	
Probability of extreme climatic event 0.4	Mini	Maxi			Minimum	Maximum	Minimum	Maximum
Houses	928	1,114	No	US$	24,327,810	48,673,097	2,984,211	3,582,340
				SAT$	63,811,846	127,669,533	7,827,585	9,396,478
Tourist accommodation	40	43	No	US$	9,952,312	17,831,227	1,220,817	1,312,378
				SAT$	26,104,914	46,771,308	3,202,203	3,442,368
TOTAL				US$	34,280,122	66,504,324	4,205,028	4,894,718
				SAT$	89,916,760	174,440,841	11,029,788	12,838,846

Table 28: Cost of damage avoided due to the presence of coral reefs, rest of Upolu (ROU)

Coastal Protection Index 0.66	Number		Unit	Currency	Total value of avoided damages		Annual value of avoided damages	
Probability of extreme climatic event 0.4	Mini	Maxi			Minimum	Maximum	Minimum	Maximum
Houses	1,082	1,298	No	US$	2,973,377	5,944,921	539,172	646,807
				SAT$	7,799,168	15,593,528	1,414,248	1,696,575
Tourist accommodation	49	52	No	US$	3,065,029	5,421,140	555,792	589,820
				SAT$	8,039,571	14,219,650	1,457,842	1,547,098
TOTAL				US$	6,038,406	11,366,061	1,094,964	1,236,627
				SAT$	15,838,739	29,813,178	2,872,090	3,243,673

Table 29: Cost of damage avoided due to the presence of coral reefs, Northwest Upolu (NWU)

Coastal Protection Index 0.63 / Probability of extreme climatic event 0.4	Number		Unit	Currency	Total *value* of avoided damages		Annual *value* of avoided damages	
	Mini	Maxi			Minimum	Maximum	Minimum	Maximum
Houses	46	55	No	US$	126,410	251,904	24,945	29,825
				SAT$	331,573	660,744	65,431	78,231
Tourist accommodation	8	9	No	US$	500,413	938,274	98,748	111,092
				SAT$	1,312,583	2,461,093	259,016	291,394
TOTAL				US$	626,823	1,190,178	123,693	170,742
				SAT$	1,644,156	3,121,837	324,447	369,625

Table 30: Cost of damage avoided due to the presence of coral reefs, Savai'i

Coastal Protection Index 0.63 / Probability of extreme climatic event 0.4	Number		Unit	Currency	Total *value* of avoided damages		Annual *value* of avoided damages	
	Mini	Maxi			Minimum	Maximum	Minimum	Maximum
Houses	32	38	No	US$	87,937	174,042	17,353	20,607
				SAT$	230,659	456,512	45,517	54,052
Tourist accommodation	20	22	No	US$	1,251,032	2,293,559	246,870	271,557
				SAT$	3,281,457	6,016,005	647,540	712,294
TOTAL				US$	1,338,969	2,467,601	264,223	292,164
				SAT$	3,512,116	6,472,517	693,057	766,346

Based on the above equation and the parameter *value*s from Tables 27 to 30, the expected annual *value* of damage to houses due to coastal flooding is given in Table 31.

Table 31: Expected value of flood damages to houses (US$)

	Apia urban area	Rest of Upolu (ROU)	Northwest Upolu	Savai'i
P_t= probability of storm surge in year t	0.4	0.4	0.4	0.4
CPI= coastal protection index	0.77	0.66	0.63	0.63
A= assets at risk (houses)	1,021	1,190	51	35
C= Construction cost (house)	53,775	5,637	5,637	5,637
DF= damage factor (% of construction cost)	0.65	0.65	0.65	0.65
D_t= expected flood damage in year t (houses)	3,283,276	592,990	27,656	18,980

The higher cost of flooding damage indicates the situation without coral reefs, where the reef morphology and inner slope *values* in the CPI are recorded as 1. The avoided damage due to the presence of coral reefs is the difference between expected flood damage "without and with" coral reefs. This is summarised in Table 32 with details given in Appendix II.

Similar assumptions are made for tourist accommodation, with a damage factor of 0.65. The expected *value* of flood damage to tourist accommodation, such as hotels and resorts, is shown in Table 33. The difference between expected flood damage to tourist accommodation with and without the effect of coral reefs is given in Table 34.

Table 32: Annual avoided damage cost to houses due to the presence of coral reefs (US$/year)

	Apia urban area	Rest of Upolu (ROU)	Northwest Upolu (NWU)	Savai'i
Expected flood damage with coral reefs	3,283,276	592,990	27,656	18,980
Expected flood damage without coral reefs	6,566,551	854,603	40,363	25,135
Avoided damage to houses attributable to coral reef	3,283,275	261,613	12,707	6,155

Table 33: Expected *value* of flood damages to tourist accommodation (US$)

	Apia urban area	Rest of Upolu (ROU)	Northwest Upolu	Savai'i
P_t= probability of storm surge in year t	0.4	0.4	0.4	0.4
CPI= coastal protection index	0.77	0.66	0.63	0.63
A= assets at risk (tourist accommodation)	42	51	9	21
C= Average construction cost (Hotels, resorts, fales)	510,375	128,311	128,311	128,311
DF= damage factor (% of construction cost)	0.65	0.65	0.65	0.65
D_t= expected flood damage in year t (houses)	1,281,856	578,447	111,092	259,214

Table 34: Annual avoided damage cost to tourist accommodation due to the presence of coral reefs (US$/year)

	Apia urban area	Rest of Upolu (ROU)	Northwest Upolu (NWU)	Savai'i
Expected flood damage with coral reefs	1,281,856	578,447	111,092	259,214
Expected flood damage without coral reefs	2,563,716	833,688	162,134	343,283
Avoided damage to tourist accommodation attributable to coral reef	1,281,860	255,241	51,042	84,069

The annual *avoided damage cost* of storm flooding for residential and tourist accommodation along the coastal areas, provided by the presence of coral reefs, can be estimated as US$7,535,962 or SAT$19,766,828. If the reefs were damaged or absent, the estimated damages from storm flooding would be around US$11,389,473 or SAT$ 29,874,588 per year.

These *values* do not include avoided damages to infrastructure and crops. Coral reefs can also play an important role in the process of erosion regulation, such as preventing shoreline recession, particularly for tourist accommodation and houses near the beaches. However, these impacts are not included in the above *values*.

6.6.4 Uncertainty

This approach is exploratory, aiming to produce an overview of the quantification and *valuation* of coastal protection provided by coral reefs against flooding from storm surges. Many uncertainties are present in every step of the approach, mainly the choice of damage function (flood damage percentage), the definition of zones at risk, choice of data used for GIS analysis, the database of assets, and *valuation* of construction costs. The analysis is highly reliant on limited sources (see Government of Samoa, 2013b; World Bank, 2013b; Pascal, *et al.*, 2015 and Salcone, *et al.*, 2016).

Assets at risk were identified as those affected by Cyclone Evan in 2012, adjusted for population growth and time period, but the *values* are still likely to be underestimated, and the damage cost of flooding is therefore likely to be much higher. In addition, if the intensity of a potential cyclone is much stronger or its direction of impact is different from Cyclone Evan, the costs are likely to be much higher.

An average construction cost figure from the World Bank report was applied to urban areas and rural areas, regardless of the type of structure and materials involved. Given that a small number of houses are multi-storey, or have a large floor area, a median cost was used in the case of urban houses. The construction and repair costs are potentially under-estimated. In particular, the average cost of rural houses has been applied to all three regions except Apia, although there are some large houses in rural areas as well.

The flood damage percentage used in the analysis was generated from estimates made by the Federal Emergency Management Agency for houses in California (Pascal, *et al.*, 2015). Houses in Samoa may suffer a higher rate of damage since their construction quality is generally lower. Again, this suggests the actual damage cost may be higher than estimated in this report. Maximum and minimum *values* shown in Tables 27 to 30 reflect these uncertainties. The minimum *value* was calculated by multiplying the estimated total number of houses by a factor of 0.75, while the maximum *value* was calculated by multiplying the total number of houses by a factor of 1.25.

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

The above coastal protection *values* can be compared to a New Caledonia study which applied the avoided cost method (Laurans, *et al.*, 2013), that resulted in an estimated US$435 per ha contribution of reefs. This equates to about

US$21,315,000 or SAT$35,169,750 in 2019 prices given Samoa's reef area of 490 km^2.

6.6.5 Sustainability

Reef, mangrove and seagrass ecosystems provide coastal protection benefits only while the ecosystems remain intact. As damage and degradation to reefs,mangroves and seagrass areas from coastal development is an ongoing threat (Burke, et al, 2008; World Bank, 2016), the magnitude of restoration services could be increased in some instances.

Effective implementation of community-based resource management plans, which integrate protection and conservation measures (such as the use of marine reserves, protected areas, use of non-destructive fishing practices and sustainable land use management practices), are some examples of strategies that encourage reef restoration. For example, a 2016 research expedition of 83 km of coastline of Upolu noted that coral cover was extremely low at approximately half of the sites surveyed, and below 10% at 78% of the sites surveyed, while the sites in MPAs had much higher levels of cover (Ziegler, *et al.*, 2018).

Climate change, in particular acidification of oceans and warmer water temperature, could impact reefs and threaten the sustainability of this *ecosystem* service. Climate change may also increase the intensity and severity of storms and their potential damage, thus increasing the importance of coastal protection services. Cyclone Evan in 2012 demonstrated that a severe storm can cause catastrophic flooding and erosion. It is difficult to estimate how much damage would have occurred without the presence of Samoa's reef and mangrove ecosystems.

6.6.6 Distribution

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

6.7 Carbon sequestration

The role of blue carbon[33] in mitigating climate change and providing benefits from coastal protection and fisheries enhancement is increasingly recognised. Atmospheric carbon dioxide (CO_2) is a major contributor to the greenhouse effect, which is causing changes to the global climate, sea temperature, sea level rise, and harmful effects to Pacific Islands communities and economies. In addition, ocean acidification occurs when CO_2 in the atmosphere is absorbed by seawater, resulting in lower sea pH levels. This reduces the availability of carbonate ions for marine animals that make calcium carbonate shells and skeletons (e.g., shellfish and corals).

Mangroves, wetlands, seagrasses, phytoplankton and even algae remove carbon dioxide from the atmosphere for storage in their fibres, in the soil, and /or in the ocean substrate (Salcone, *et al.*, 2016). This *ecosystem* service of carbon storage occurs through a biophysical process referred to as carbon sequestration where carbon is removed from the atmosphere and/or prevented from release into the atmosphere.

6.7.1 Identify

The natural growth process of seagrass, mangroves and other plants absorbs carbon from the air. Some carbon is released back into the atmosphere during cell respiration, some is added to the plant's biomass, and some deposited into the soil or ocean substrate. Carbon stored in the biomass of mature plants is relatively constant but can be released into the atmosphere if plants are killed, decay or burn. Carbon stored near the soil surface may be gradually released if the soil remains unvegetated, or released quickly if disturbed (Murray, et al 2011). The rate at which carbon is added to biomass and substrate, and the potential release of stored carbon are both important. Together, they represent the net CO_2 removed from the atmosphere and prevented from release into the atmosphere.

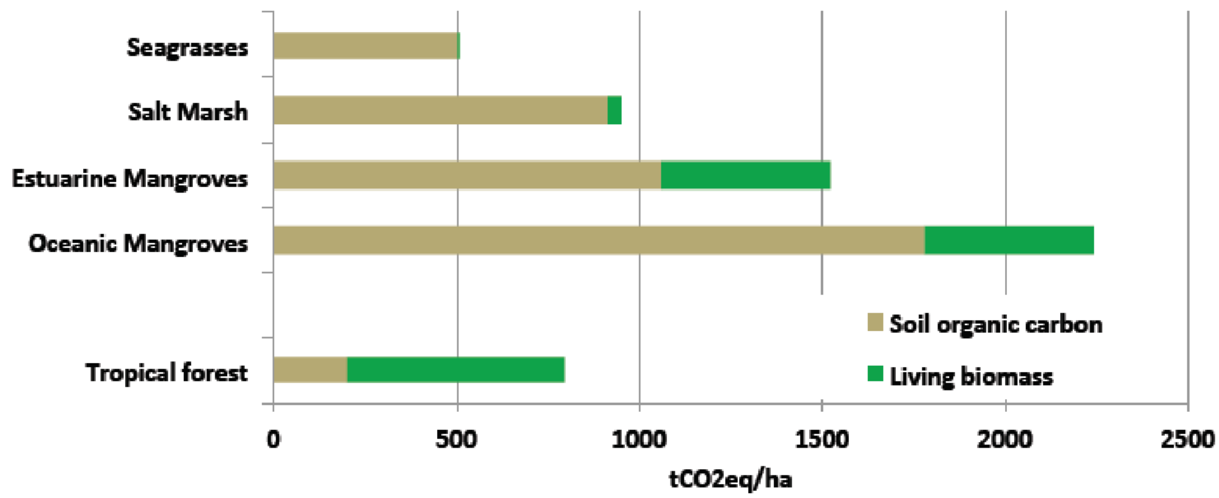
The amount of carbon captured and removed from the atmosphere by different plant species can be quantified in terms of a net rate of sequestration. The net amount of

33 Blue carbon refers to organic carbon captured and stored by the oceans and coastal ecosystems, particularly by vegetated coastal ecosystems such as seagrass, mangroves and tidal marshes.

carbon sequestered by an *ecosystem* in a given time period is the sum of the rate of sequestration of each species and the release of stored carbon (Howard, et al 2014).

The magnitude of the *ecosystem* service depends on the prevalence of the ecosystems that sequester and store carbon. Studies have shown that intact, growing mangroves and coastal wetlands sequester more carbon each year than tropical rainforests (Murray, *et al.*, 2011). The destruction of these ecosystems halts the sequestration process and may result in the stored carbon being released into the atmosphere if plants and trees are burned or decomposed, and if the soil is exposed to oxygen (Salcone, *et al.*, 2015). Figure 28 shows the relative amounts of carbon typically stored in different ecosystems. Oceanic (coastal) mangroves are capable of storing more carbon than any other ecosystem.

Figure 28: Carbon storage abilities of different types of habitats



Source: (Murray, *et al.*, 2011: 7)

Phytoplankton has a big effect on the levels of CO_2 in the atmosphere by absorbing CO_2 during photosynthesis. Phytoplankton is a natural sink, and one of the ways CO_2 is absorbed from the atmosphere. An improved understanding of how ocean phytoplankton sequester and store carbon and how humans could impact this process is still required.

The occurrence of mangroves in Samoa marks the eastern limit of their Indo-Pacific mangrove distribution (Thollot, 1993). Only three species of mangroves are present in Samoa - (Siamomua-Momoemausu, 2013 b) the *Rhizophora samoensis* is found on the seaward fringe below the high-water mark, the *Bruguiera gymnorrhiza* grows on the landward side, and the *Xylocarpus granatum* mangrove occurs on white sand substrate at a stream mouth near Salailua on Savai'i Island (Siamomua-Momoemausu, 2010). The largest mangrove area in Eastern Polynesia is considered to be in Vaiusu Bay near Apia (Iakopo, 2006). This mangrove stretches from Mulinu'u Peninsula to Vaiusu. The Saanapu and Satoa mangrove forest is on the west of Safata Bay on the south coast of Upolu, while the Le Asaga mangroves are on the eastern side of the Safata Bay.

6.7.2 Quantify

A mangrove audit report in 2010 identified the total area of mangroves in Samoa as 752 ha (Siamomua-Momoemausu, 2010; Saifaleupolu, 2015), while another study noted that the total area of mangroves in Samoa as 374 ha (Percival, 2018; Government of Samoa and Conservation International, 2019). In 2013, mangrove biomass data were collected from 11 plots located in the two dominant mangroves in Samoa, under the MESCAL project (Duke, 2013; Siamomua-Momoemausu, 2013b). The average above and below ground biomass of carbon was estimated for each of the vegetation types as part of the project, and is shown in Table 35. Biomass carbon multiplied by 3.67 results in a conversion to the CO_2 equivalent.

Table 35: Carbon storage by mangrove species in Samoa

	Biomass carbon (t/ha)		Total CO_2 equivalent (t/ha)
	Above-ground	Below-ground	
Bruguiera gymnorrhiza	134.9	124.8	953
Rhizophora samoensis	39.5	54.5	345

Source: (Duke, 2013)

The above data for *Rhizophora samoensis* (which is the dominant mangrove species in Samoa [per. comm: Siamomua-Momoemausu, 20 September 2020] also aligns with estimates generated from the Blue Carbon Initiative assessment of 237t CO_2/ha – 563t CO_2/ha for the different types of mangroves around the world.

If mangroves are destroyed, the total carbon dioxide released would depend on the treatment of the mangrove biomass and the carbon stored in the soil. If mangrove wood is used to build houses and furniture, much of the carbon will remain in the wood structure; if the mangrove wood is burned, most carbon will be released into the atmosphere as CO_2. The fate of carbon in the soil when mangroves are destroyed is also important. This study is only concerned with the top metre of soil and assumes that deeper stored carbon will remain in the soil indefinitely.

The highest release of biomass and soil carbon would occur in the first few years after the destruction of the mangroves and gradually decrease over time. Eventually, all biomass carbon and most soil carbon may be released into the atmosphere. Because the future uses of land after mangrove destruction (e.g. agriculture, aquaculture, or commercial development), is unknown, for the purpose of this assessment carbon release is estimated over 15 years following land-use conversion.

Using the estimates from Murray *et al.* (2011), an assumption has been applied of 75% of biomass carbon release in the first year, and a remaining 25% decaying with a half-life of 15 years. Thus, the quantity of biomass carbon released into the atmosphere during the 15 years following mangrove loss is:

Biomass carbon released per ha:

$(237\ t\ CO_2/ha \times 0.75) + ((237\ t\ CO_2/ha \times 0.25)\ /2) = 207.4\ t\ CO_2/ha$

$(563\ t\ CO_2/ha \times 0.75) + ((563\ t\ CO_2/ha \times 0.25)\ /2) = 492.6\ t\ CO_2/ha$

The amount of carbon stored in the top metre of soil beneath mangroves (see Murray *et al.*, 2011) is between 1,690 t CO_2/ha and 2,020 t CO_2/ha. The rate at which this is released is assumed to have a half-life of 7.5 years. Therefore, the quantity of soil carbon released into the atmosphere in the 15 years following mangrove loss is:

$(1{,}690\ t\ CO_2/ha \times 0.5) + (845\ t\ CO_2/ha \times 0.5) = 1{,}267.5\ t\ CO_2\ /ha$

$(2{,}020\ t\ CO_2/ha \times 0.5) + (1{,}010\ t\ CO_2/ha \times 0.5) = 1{,}515\ t\ CO_2\ /ha$

Over the next 15 years, forgone sequestration from 1 ha of mangrove lost is:

$15\text{-year} \times 6.3\ t\ CO_2\ /ha/year = 94.5\ t\ CO_2\ /ha$

The total additional, or potentially avoided, CO_2 in the atmosphere (after 15 years) resulting from 1 ha of mangrove loss is the sum of the foregone sequestration and released carbon from biomass and soil:

$94.5 + 207.4 + 1{,}267.5 = 1{,}569.\ 4\ t\ CO2/ha$

$94.5 + 492.6 + 1{,}515 = 2{,}102.1\ t\ CO2/ha$

Table 36 shows the estimated carbon emissions from the destruction of mangroves by carbon source. The total potentially avoided CO_2 in the atmosphere is estimated by multiplying the quantity of emissions per ha by the area of predicted mangrove loss per year.

Table 36: Estimated carbon emissions from the destruction of mangroves by carbon source

	Tonnes of carbon per hectare over 15 years	
	Minimum	Maximum
Biomass	207.4	492.6
Soil	1,267.5	1,515
Foregone sequestration	94.5	94.5
15-year total	1,569.4	2,102

Data on mangroves in Samoa from 2010 to 2019 suggests the annual average loss of mangroves is about 6.3%. Therefore, the potentially avoided amount of CO_2 is estimated as 37,028.4 t CO_2/year to 49,607.2 t CO_2/year.

Potentially avoided amount of CO2 = 1,569 t CO2/ha x 23.6 ha/year = 37,028.4 t CO2/year

Potentially avoided amount of CO2 = 2,102 t CO2/ha x 23.6 ha/year = 49,607.2 t CO2/year

Three species of seagrass - *Halophila ovalis; H. ovalis ssp. bullosa and S. isoetifolium* - are the only taxa recorded in Samoa (Skelton & South, 2006). Further research is however needed to document their location and distribution, as well as to explore their presence in deeper subtidal zones (Government of Samoa and Conservation International, 2019). The Blue Carbon Initiative[34] estimates the average sequestration rate of seagrass to be approximately 4.4 t CO_2 /ha/year. Approximately 0.4 to 18.3 t CO_2 /ha[35] are stored in the biomass and approximately 500 t CO_2 /ha in the seagrass soils[36] (Sifleet, *et al.*, 2011). Given the limited knowledge about seagrass areas in Samoa, these figures could not be used in the *valuation* of *ecosystem services* for carbon storage.

6.7.3 Value

Two distinct approaches to valuing the human benefits associated with carbon sequestration exist. The first approach is to measure the marketability of carbon offsets i.e. selling assurance that a carbon sequestering *ecosystem* will be protected from destruction and thereby reduce the amount of CO_2 in the atmosphere. This is termed as the *market value* of carbon sequestration. The second approach is to measure the avoided *social cost of carbon*. The *social cost of carbon* (SCC) is the probable harm from additional CO_2 in the atmosphere. The SCC is the cost of emitting one additional tonne of CO_2 each year, in monetary terms. This *value* can be used to weigh the benefits of reducing global warming against the cost of reducing emissions.

Market value, where it is realised, is an immediate and localised benefit that may accrue to those individuals who can protect an *ecosystem* from destruction, verify the carbon sequestration properties of that ecosystem, and sell the verified amount of carbon offset to willing buyers. The avoided SCC is a global *value*; it is a benefit that accrues to all who may suffer the consequences of climate change. The SCC more accurately represents the true benefits of carbon sequestration but may be less interesting to stewards of carbon sequestering ecosystems, who potentially stand to gain financially from selling carbon offsets.

It is important to consider 'additionality' when estimating the carbon offset *value*, i.e. how much of the carbon sequestering *ecosystem* would have been destroyed in the absence of the potential offset payment. Only areas that have been destroyed and can be rehabilitated, or areas that are likely to be destroyed, can be considered 'additional'. it is not possible to sell a carbon offset for an area that is

34 The International Blue Carbon Initiative is a coordinated global program focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems.
35 (Duarte & Chiscano, 1999)
36 Seagrasses vary considerably by species and location. In some areas, sequestration rates are near zero or even negative (respiration > sequestration). CO2 stored in seagrass soil ranges from 66 t CO2/ha to 1,467 t CO2/ha.

unlikely to be destroyed, because carbon emissions would not be 'saved' from release into the atmosphere.

The estimated SCC used by the US EPA and other agencies for appraisal of emissions reduction in 2020 is US$62, *discounting* future damages annually at 2.5%[37]. Based on this estimate, the sequestration rates above, and the total estimated area of mangroves in Samoa, the annual social benefit of sequestration from mangroves is US$146,084 or SAT$344,758.24, as summarised in Table 37.

37 EPA Fact Sheet – Social cost of carbon. 19 january2017/ snapshot.epa.gov/sites/production/files/2016-12/documents/ social_cost_of_carbon_fact_sheet_pd. (19 September 2020).

The carbon market prices can be used in financial assessments of conservation or restoration projects to reflect potential *revenues* for the project. The potential *value* of carbon offsets is directly related to the area of mangroves and/or seagrass that can be protected from destruction and rehabilitation. Data from mangrove reports between 2010 (Siamomua-Momoemausu, 2010) [752 ha] and 2019 (Government of Samoa and Conservation International, 2019) [374 ha] give an annual average loss of mangrove as 6.3%, which equates to a loss of 23.6 ha per year. Using the above data and the current average market price of carbon of US$2 /t of CO_2 (World Bank, 2020, p. 8) for avoided emissions, we can say that the *market value* of preventing mangrove loss in one year in Samoa is between US$74,075.6 and US$99,219.2 as shown in Table 38.

Table 37: *Value* of carbon of sequestration by mangroves

	Units	*Values*	Source
Mangrove area	Hectares (ha)	374	(Percival, 2018) (Government of Samoa and Conservation International, 2019)
Carbon sequestration rate	t CO_2 /ha/year	6.3	(Murray, Pendleton, Jenkins, & Sifleet, 2011)
Carbon sequestered per year	T CO_2 /year	2,356.2	
Social cost of carbon	US$ /t CO_2	62	US EPA (2017)
Annual avoided costs - *value* of carbon sequestration	US$ SAT$	146,084.4 384,201.97	

Table 38: Potential market value of carbon sequestration by mangroves in Samoa

	Units	*Values*		Source
		Minimum	Maximum	
Mangrove area	ha	374	374	
Annual rate of loss	%	6.3	6.3	

	Units	*Values*		Source
		Minimum	Maximum	
Annual area loss	ha	23.6	23.6	
Carbon sequestration rate	t CO_2/ha/yr	6.3	6.3	(Murray,*et al.* 2011)
Mangrove biomass carbon	t CO_2/ha	237	563	(Murray,*et al.* 2011)
Soil biomass carbon	t CO_2/ha	1690	2020	(Murray,*et al.* 2011)
Biomass carbon initial release Biomass carbon half-life	%	75	75	(Murray,*et al.* 2011)
Soil carbon (top 1 m) half-life	yr	15	15	(Murray,*et al.* 2011)
Carbon release from biomass (15 yr)	years	7.5	7.5	(Murray,*et al.* 2011)
Carbon release from soil (15 yr)	t CO_2/ha	207.4	492.6	
Foregone sequestration (15 yr)	t CO_2/ha	1,267.5	1,515	
Carbon emissions (15 yr total)	t CO_2/ha	1,569.4	2,102.1	
Annual carbon release	t CO_2	37,037.8	49,609.6	
Market price of carbon	US$/ t CO_2	2	2	(World Bank, 2020)
Market value of protecting mangroves per year	US$ SAT$	74,075.6 194,818.83	99,219.2	

There is a difference between the *value* of carbon sequestration measured as a social benefit of sequestration (Table 36), and the potential carbon offsets (Table 37). This highlights how the *willingness-to-pay* of buyers in the voluntary carbon market does not match the real benefit from avoiding the release of a tonne of CO_2 in terms of avoided damage from climate change. Even small payments for this *ecosystem* service can act as an incentive and raise conservation interest as an approach compared to no payments.

6.7.4 Uncertainty

Only mangroves have been quantified in this report due to data available on the quantification of carbon sequestration by marine ecosystems. Therefore, these *values* can be regarded as an underestimate of the *real economic values* of carbon sequestration by ocean and coastal ecosystems in Samoa as this study does not include sequestration by whales and seabirds due to lack of data. Uncertainty also exists about the CO_2 conversion rates used above, as these are based on global studies (Murray, *et al.*, 2011), and data obtained from field study reports for the MESCAL Samoa project. For example, the dominant mangrove type in Samoa is *Rhizophora*, but these generally store less carbon in biomass than *Bruguiera gymnorrhiza*. Protecting and rehabilitating *Bruguiera gymnorrhiza* is likely to increase CO_2 savings and possible carbon offset *value*.

Uncertainty is also related to the price of carbon. The *social cost of carbon* is intended to be a comprehensive estimate of climate change damage, but due to *current* limitations in integrated assessment models and data, *values* may not include or may underestimate important damage from CO_2 emissions. The carbon offset *value* is based on the market price for CO_2. This is dependent on a voluntary market where price is driven by market demand. Arguably, mangrove managers could sell mangrove protection offsets at a much higher price than the current average CO_2 market price of US$2 t/$CO_2$ if commitments to protect biodiversity, bird and fish reproduction, or other mangrove attributes were included as part of the offset package.

There is high uncertainty about the current area of mangroves in Samoa and the area of mangroves at risk of destruction. The estimated average annual loss of mangroves over the last 8 years has been higher than the global average annual rate loss of about 2.1% (United Nations Environment Programme, 2006:3). It could also be likely that under the village resources management initiatives, some communities are protecting their mangroves, while other areas such as those near Apia, are increasing pressure for reclamation, and development resulting in increasing pollution, which are contributing to the loss.

6.7.5 Sustainability

Protected mangroves and seagrass continue to sequester carbon into the soil until they are disturbed. In addition, mangroves and seagrasses provide habitat for fish and other invertebrates, thereby contributing to other *ecosystem services*.

Given that Samoa is at the eastern end of the Indo-Pacific mangrove zone and harbours only three dominant species of mangrove and a high rate of loss. This continued rate of loss should generate concern. According to the current status quo, the mangrove population would be significantly reduced in less than 16 years. The second dilemma is that good mangrove management and rehabilitation programmes are needed to ensure mangroves remain as healthy intact forests rather than in isolated patches, as the latter structure is likely to compromise the accrued benefits from mangroves as an 'ecological system' which supports various *ecosystem services* to humans. The size of mangroves in Samoa is relatively small in the context of recognizing costs and benefits associated with the carbon offset mechanism.

It is also possible to enhance sustainability through a significant increase in community commitment to willingly invest in the conservation and protection of their mangroves. Government and donor programmes supporting mangrove restoration would also help (Pers. comm: Maria Satoa, 24 September 2020).

6.7.6 Distribution

Atmospheric carbon causing climate change is a global concern. Selling carbon offsets benefit global commons rather than specific consumers/producers as they are accrued by the resource stewards, presumably local communities. The benefits to private/consumers who purchase carbon offsets is limited and related to their *willingness-to-pay* for verification that carbon is being stored in natural sinks rather than released into the atmosphere.

6.8 Research, education, and management

This report has highlighted the critical importance of coastal and marine ecosystems to Samoa's economy. If these ecosystems and their productive capacities are significantly damaged or destroyed, the cost to the economy would be enormous and long-term. Benefits can be enjoyed by society in a sustainable manner if ecosystems are managed well. Research, education and management play a pivotal role in identifying and addressing both the costs and benefits in this regard (for example, work done on biodiversity conservation and protection to ensure *ecosystem* integrity).

As mentioned above, Pacific Island countries are fundamentally dependent on oceans, and highly vulnerable to threats from climate change and natural disasters due to their location. Donors and development agencies prioritise the advancement of the marine sector because of the potential it holds for the Pacific people and the global community given the vast ocean areas under their national jurisdiction that remains understudied.

These institutions also realize the need to address the imminent threats to PICTs from climate change such as rising sea levels, ocean acidification, pollution of freshwater aquifers, and extreme climatic events. Therefore, simultaneously strengthening adaptation and mitigation measures, while building the resilience of Pacific people remain a central focus of governments, donors and development agencies. Also essential is expanding the knowledge and understanding about the marine resources and their dynamic environments through research and investigation. However, quantifying the *value* of benefits from such activities at a national level is difficult.

6.8.1 Identify

One method to quantify the *value* of *ecosystem services* in terms of its contribution to research, education and management, is to *evaluate* the amount of public funds redistributed to help protect the marine and coastal ecosystems, such as through protection of their biodiversity. Funds providing educational opportunities to students, investment for education and research institutions, and community outreach programmes for NGOs, and civil society groups, could also provide some indication in this regard.

Domestic government expenditures represent a redistribution of resources, not a true *economic benefit*, but foreign aid from developed countries, international organisations, NGOs and private donors can be counted as a benefit contributing significantly to the economies of most Pacific Island countries. For example, MSP is funded by German tax *revenue*. The taxation may represent a cost or a benefit to German taxpayers, depending on whether they want to pay for biodiversity conservation in the Pacific. For MSP countries, this redistribution is a benefit, although it should be noted that a portion of the expenditure contributes to salaries of foreign nationals working in the Pacific. In addition, costs associated with acquiring, managing and implementing these projects need to be subtracted from the funds received.

6.8.2 Quantify

Disaggregated information on the funds for specific research, education and development related to coastal and marine ecosystems is not available. However, funds are often allocated to particular economic and social sectors; Table 39 shows the level of foreign aid cash grant and in-kind contributions to Samoa for the fiscal year 2019/20. The total cash grant and in-kind contribution amounted to SAT$306.89 million, which is equivalent to about 14% of Samoa's GDP. The donor cash grant represented about 25% of the total government budget of SAT$914.1 million (Tuiotis, 2019, p. 7). This is equivalent to 40% of the total government *revenue* from taxes and other sources of SAT$575.6 million (Government of Samoa, 2020).

Table 39: Estimated utilization of foreign aid cash grant and in-kind contribution to Samoa FY 2019- 2020

Sector	Cash Grant	In-Kind	Total
Community development and NGO	5,534,518	2,772,848	8,307,366
Education	5,343,157	21,540,121	26,883,278
Health	58,296,986	5,053,283	63,350,269
Law and justice	977,914	17,182,388	18,160,302
Public administration	-	709,206	709,206
Agriculture	5,924,219	1,540,521	7,464,740
Commerce/trade	283,241	1,369,610	1,652,851
Tourism	5,515,951	7,265,295	12,781,246
Communications	12,739,840	542,682	13,282,522
Energy	2,704,817	-	2,704,817
Transport and infrastructure	65,937,990	11,820,093	77,758,083
Environment	16,292,243	3,735,148	20,027,391
Multi-sector	15,328,736	3,412,464	18,741,200
Water and sanitation	12,035,107	118,201	12,153,308
Finance	22,910,087	-	22,910,087
TOTAL	**229,824,808**	**77,061,860**	**306,886,668**

Source: (Government of Samoa, 2020)

Approximately eight NGOs in Samoa are involved in environment management and conservation. For example, Conservation International focuses on three main issues that directly relate to coastal and marine habitats i.e., overfishing, habitat destruction and ocean acidification associated with climate change. Conservation International (Samoa) has been working to address fishing pressure in coastal areas with the Fisheries Division and SPC. A local NGO (*O Le Siosiomaga Society Inc)* focuses on advocacy and education to help communities address their environmental issues and concerns, such as protection of mangroves, lagoons and reef areas as reserves.

Similarly, the Samoa Conservation Society engages with communities to raise their awareness on practicing sustainable livelihoods and conservation work. One of their projects involved working with the Fisheries Department and MNRE to train communities in removing Crown Of-Thorns (Cots) starfish that damage the reefs (Samoa Conservation Society, 2020). Information on external funds allocated to specific environmental projects of NGOs was not available.

6.8.3 Value

Costs associated with attracting and spending international aid that should be deducted from the *gross revenue* flows to determine the true social benefit of these monies. Estimations of these costs could not be identified. The estimated allocation of foreign aid for projects related to fisheries, coastal and marine resources and climate change forFY 2019-20 and 2020-21 is shown in Table 40.

Table 40: Estimated utilization of foreign cash grants to projects related to coastal and marine ecosystems and climate change for fiscal years 2019/20 and 2020/21

Sector Projects	Development partner	FY 2020/21 SAT($)	FY 2019/20 SAT($)
Agriculture			
Reef colonization and socio-*economic impacts* from trochus translocation to Samoa	GoA - ACIAR	50,270	58,032
Strengthening of fisheries information management	FFA	300,000	-
Fisheries development project for small scale pelagic fisheries	FFA	200,000	782,697
US Treaty on economic development fund	FFA	500,000	1,333,264
Samoa agriculture and fisheries productivity and marketing	World Bank	11,056,641	1,307,121
Samoa agriculture and fisheries productivity and marketing	IFAD	1,224,521	-
Tourism			
Sustainable tourism for green/blue livelihoods	UNESCO	-	66,021
Construction of Apia waterfront early development projects	GoNZ - MFAT	-	5,325,664
Transport/Infrastructure			
Climate resilience of West Coast Road	World Bank	7,230,730	14,378,333
Samoa climate resilient transport project	World Bank	13,617,675	11,764,091
Construction of Apia waterfront early development projects	GoNZ - MFAT	1,013,748	-
Pacific risk tool for resilience	NIWA	-	79,885
Environment			
Enhancing climate resilience of coastal resources and communities (PPCR)	World Bank	11,170,064	7,059,108
Economy-wide integration of climate change adaptation and disaster risk management (EWACC)	GEF/UNDP	3,533,520	2,561,958
Pacific resilience programme (SPREP Samoa)	World Bank	2,100,000	5,228,485
Strengthening national decision making towards ratification of the Minamata Convention	UNITAR	15,331	-
GEF Pacific ridge to reef (R2R) integration of water (IW)	GEF/SPC	142,893	-
Enhancing the conservation and wise use of Vaipu Swamp Forests	IUCN/NWF	20,347	-
Strengthening critical landscapes	GEF/UNDP	-	1,176,409
Disaster risk management	GoNZ/MFAT	-	266,283
Multi-sector			
Integrated flood management to enhanced climate resilience of the Vaisigano catchment	GEF/UNDP	2,681,396	14,378,333
Total Foreign – cash grants to projects related to coastal and marine resources, climate change		54,857,136	65,765,684

Source: (Government of Samoa, 2020)

The above table only provides a broad estimate of projects presumably linked to some aspect of research, education and management relating to coastal and marine resources. However, it is difficult to determine exactly what proportion of these funds are specifically dedicated to marine and coastal ecosystems. According to Table 40, SAT$ 65, 765,684 of donor funds allocated to marine, coastal and climate change adaptation and building resilience amount to about 28.6% of the total donor cash grant funds allocated for FY 2019/20. Therefore, it is estimated that the *value* of research, management and education relating to marine and coastal ecosystems in Samoa is at least SAT$65.8 million or US$24.8 million. The total *gross value* is likely much higher, although administration costs should be subtracted to determine the true net social benefit.

6.8.4 Uncertainty

As noted above, funding is often available under thematic areas, and has multiple and overlapping objectives, thus making it difficult to separate the allocation of funds to specific coastal and marine *ecosystem services*. For example, should the *Climate Resilience of the West Coast Road* project under the Transport and Infrastructure Sector be aligned with the protection of coastal and marine ecosystems, or to transportation and communication activities? Arguably, having a more durable coastal road will reduce erosion and therefore sedimentation in coastal areas, which in turn will support the functioning of the coastal ecosystems.

Government aid monies are an example of just one stream of research and education funds. Researchers from foreign institutions benefit Samoa through their personal expenditure, employment of research assistants and sharing of new knowledge and findings. Tertiary institutions such as the Maritime School of the National University of Samoa, the University of the South Pacific and the Samoa International Research and Scientific Organisation, may also engage in collaborative research with overseas institutions through exchange programmes that provide capacity building and technical support, but such benefits are difficult to specifically quantify. Identifying ways to capture the benefits of research and education will become increasingly important to provide a better understanding of the total *value* of the services provided by marine and coastal ecosystems.

6.8.5 Sustainability

Research, education and management can include both direct and indirect activities. Although they cannot be categorically labelled as sustainable, activities related to biodiversity research, education and management are targeted towards scientific inquiry that supports sustainable resource management, and therefore create positive impacts. Furthermore, research and education funds may depend on the presence of healthy and diverse ecosystems, which creates an incentive for sustainable use and management in addition to maintaining diplomatic relations with donor agencies on common development issues and concerns.

6.8.6 Distribution

The distribution of research and educational funds depends on the conditions attached to the funds by the donors. The direct beneficiaries are recipients such as the researchers and project implementers, the communities, students, and the government. In the case of collaborative research, benefits also accrue to any overseas partners brought in for the work. A persistent criticism of international aid is that a large proportion of the benefits return to citizens of the donor countries in the form of salaries paid to international consultants and project managers. While the number of aid dollars and in-kind assistance is quite large, not all the funds are of direct benefit to Samoa.

6.9 Other values

Examples of coastal and marine *ecosystem services* found in Samoa though not included in this research due to lack of data and information are given below.

6.9.1 Mariculture

Experimental aquaculture involving trials of various species has been facilitated by the Fisheries Division in Samoa over several years. Aquaculture is widely recognised as a viable means of increasing fisheries production, meeting supplement dietary needs, and generating income for local communities (Secretariat of the Pacific Community, 2012; 2013). Gillett (2016) noted that in 2014, about 12 t of tilapia (freshwater fish) production was used for local consumption, with a *value* of SAT$66,000. In FY 2016/17, about 60 active farms generated an annual production of 4,334 kg (Ministry of Agriculture & Fisheries, 2018).

Marine aquaculture practiced in a marine water environment is known as mariculture. Some of the marine species that have either been already investigated or are currently under experimental trials include: Pacific oyster *Crassostrea gigas*, *Trochus Niloticus*, *Tridacna gigas*, *T. derasa*, *Caulerpa racemosa*, *Hairy black fish Actinopyga miliaris* and *leopard fish Bohadschia argus*.

Based on prior trial operations and feasibility assessments, the Samoan Aquaculture Management and Development Plan (2013 – 2018) developed a priority matrix, which among other things, identified four key marine species for mariculture to target: sea grapes, mullet and trochus, and giant clams. Giant clams are high *value* commodities that attract interest from the marine aquarium market, and also a delicacy for Samoans. Currently, the Fisheries Division hatchery provides spats to communities for culture and re-stocking of village fish reserves. Mullet is also a highly sought commodity in the local market and is a priority for mariculture development because wild stocks can be obtained locally to produce fingerlings. Sea grapes are naturally available locally in some locations with trials underway to expand cultivation in other areas. Trials for trochus and sea cucumbers are also underway.

Although experimental trials are being conducted, it is worth noting that mariculture relies on the *ecosystem services* of good quality seawater and appropriate habitat for the growth of the species in question. For example, good quality cultured fish will result from healthy ecosystems that support its ideal growth patterns. Therefore, we can see that mariculture remains an interconnected part of the *ecosystem* in which it occurs, even where a high degree of human intervention is required, such as infrastructure support and feeding. High-*value* cultured black pearls from black-lip pearl oysters (*Pinctada margaritifera*) in French Polynesia and the Cook Islands rely on clear, unpolluted and highly saline waters in temperature between 25°C to 30°C.

As with agroecosystems, under certain circumstances mariculture can support many of the same fundamental goods and services provided by nature. For example, restocking of oysters and clams helps support important biophysical processes through filtration, denitrification, stabilisation of sediments and shorelines, and creation of habitat for associated species (Heidi, *et al.*, 2019). Mariculture also provides an opportunity to maintain and reinstate *ecosystem services* in the oceans lost through overfishing and habitat destruction. Stock selectively bred in hatcheries that are disease resistant can be used for restoring reefs (Heidi, *et al.*, 2019).

6.9.2 Bioprospecting and other option value

Bioprospecting is the process of discovering and commercialising new products from natural sources. Marine resources, particularly in areas with high biodiversity such as coral reefs, or with unique ecology such as deep-sea thermal vents, may have potentially marketable products, or elements that could lead to marketable products. For example, there has been increasing interest in marine microbes, particularly bacteria, with studies demonstrating that they are a rich source of potential drugs (Commonwealth Secretariat, 2016). The potential use of marine organisms and their by-products as a rich source of mineralising porous organisms has also been demonstrated. These outcomes can provide clues for bone tissue engineering to support bone repair and regeneration (Clarke & Walsh, 2014). If marine bioprospecting is not currently implemented in Samoa, it represents an *option value* i.e. the resources have a *value* today because they present the option for new discoveries or future commercialization.

Marine genetic resources found within the EEZ of a country are subject to the laws and regulations of the national jurisdiction, including access and benefit sharing laws (ABS).[38] Samoa would need ABS related laws specific to regulating bioprospecting of genetic resources to ensure the country benefits from any discoveries. This is particularly important for small states to mitigate potential exploitation, given their reliance on international technological and scientific knowledge and foreign businesses (Commonwealth Secretariat, 2016). Introducing ABS laws and tightening legal and regulatory frameworks will be important if small states are to receive their share of *economic benefits* and ensure long-term environmental and resource sustainability.

For example, the experience of the access and benefit sharing agreements for research and development and bioprospecting of the Mamala tree (*Homalanthus nutans*) in Samoa provides a good case study. An agreement was

38 The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their Utilization to the Convention on Biological Diversity. Nagoya Protocol on Access and Benefit Sharing (ABS) is a 2010 supplementary agreement to the 1992 CBD. It aims to ensure implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity. It sets out obligations for contracting parties to take measures in relation to access to genetic resources, benefit-sharing and compliance.

established for the use of traditional knowledge held by local healers and the corresponding use of the Mamala plant for HIV-AIDs research (Ahmed, 2018). This case demonstrates the development of benefit sharing schemes which link bioprospecting to marine conservation actions led by local communities.

6.9.3 Bioremediation

In addition to providing habitat for inshore fisheries, protecting the coastline from erosion and sequestering carbon, mangroves and coastal wetlands play an important role in filtering and remediating polluted water. Mangroves absorb excess nutrients and prevent pollutants from entering water bodies, while enabling the tidal export of large amounts of organic detritus, thus supporting the productivity of the adjacent coastal ecosystems. This *ecosystem* service is known as bioremediation.

A meta-analysis of mangrove *valuation* study by Salem and Mercer estimated the mean *value* of water purification and waste assimilation provided by mangroves as US$4,748 per ha per year (Salem and Mercer, 2012: 369). Using benefit transfer, this amounted to SAT$6,623.46 per ha per year (Ram-Bidesi, *et al*., 2014) for Samoa in 2014. On this basis, the regulating function of mangroves in Safata District was estimated as SAT$1,960,742.86 per year. It was assumed that this contribution was the same for all mangrove types (taking into consideration the type and size of the mangrove forest, its geography, and surrounding activities will influence the true extent of bioremediation services). The study argued that a number of freshwater natural springs adjacent to mangrove forests in Safata district act as an important water source. The presence of mangroves allows filtration of sediments, thus helping purify water into a usable form. For example, following the tsunami disaster and the 2012 flood, local communities heavily relied on these natural springs for their water supply.

Although Samoa has relatively small mangrove forests, encompassing areas such as in Saanapu and Satoa, Le Asaga and the Vaiusu, communities can still benefit from the bioremediation which reduces the level of sediments in downstream water flow.

6.9.4 Handicrafts

Handicraft production is an important activity in Samoa that contributes to local economies. Handicrafts are sold in Fugalei market, Savalalo Flea market and Salelologa market, and in souvenir and jewellery shops and art and cultural outlets. Souvenirs are also exchanged within communities during festive occasions. Handicrafts are therefore produced for commercial sale and for personal use.

Marine ecosystems provide materials for many Samoan handicrafts. Seashells, fish bone and coral materials are used to make traditional and contemporary handicrafts such as necklaces, pendants, bracelets and hair accessories. The whale's teeth necklace (*Ula nifo)* is a highly *value*d commodity in Samoa traditionally worn by chiefs as a symbol of status and wealth. Nowadays, replicas are made from plastic decorated with dark soap seeds.[39] Similarly, turtle shell hair combs which have long been adored in Samoa, are now being replaced by faux turtle shells. These examples demonstrate that while the ocean provides potential sources of materials for handicraft production, the extractive nature of these activities can also adversely impact their supply.

Commercial handicrafts earn vendors a *resource rent*, as with any market good that depends on 'free' natural inputs that may be locally sourced from the ocean. The *resource rent* is the *net value* of the product after the *value* of labour time and other production costs have been subtracted. Handicrafts used at home have an avoided-cost *value*, meaning their *value* reflects the amount the household does not have to spend to purchase the items.

6.9.5 Ocean-based renewable energy

Ocean based energy sources have received increased interest in recent decades (Commonwealth Secretariat, 2016) given growing concern over climate change and increasing interest in renewable energy. Ocean-based energy includes sources of energy obtained from harnessing certain characteristics of the ocean power such as waves and tides, or by using ocean space for offshore wind energy. Moving towards renewable energy sources is a priority for small island countries.

The first comprehensive study to map the waves was conducted by SOPAC in six Pacific Island countries (including Samoa), from 1989 to 1994 (Krishna, 2009). According to the study, although potential exists to produce wave power energy in the region, the capacity and financial resources to

39 Samoa-Talofa: blackpearlsdesigns.com/collections/Samoa. (Accessed 7 October 2020)

adapt and sustain energy conversion technologies remain weak (Commonwealth Secretariat, 2016). Since energy generation activity, or any related research and exploratory activity based on ocean wave resources is non-existent, the magnitude of this *value* cannot be determined. However, it can be gleaned that that ocean wave energy has an *option value* for potential future use.

6.9.6 Aesthetic values

Aesthetic experience is considered the basis of aesthetic *value* and has been characterised as a feeling of pleasure or admiration in response to perceptual qualities, forms and meanings in relation to an object (Brady & Prior, 2019). For example, a particular coral reef might be given an aesthetic *value* because of its aesthetic qualities, such as richness in species biodiversity, variety of colours, geomorphology, and water clarity. Aesthetic experience is particularly important as it reflects some of the most intimate links people have with the ecological environment that supports their emotional sustenance. It varies according to the scale at which the natural environment is organised, combined with the scale of human perception (Tribot, *et al.*, 2018). As a result, aesthetic *values* have a strong potential to influence people's motivation for biological conservation at both *ecosystem* and species levels. Assessing the aesthetic *value* of ecosystems, and identifying their relationships with biodiversity attributes, is thus an important factor that needs improved integration into *ecosystem* management and conservation.

The aesthetic *value* of marine and coastal areas is seen as an *ecosystem* service comprising different attributes and is not typically directly paid for. The *economic value* of aesthetic areas is often revealed through associated markets, particularly tourism, recreation, and housing. Where this service is a component of market-based tourism and recreation (e.g. sailing, surfing, staying at seaside resorts), the *value* has already been captured by measurement of those *ecosystem services* i.e.aesthetic *value* is a component of the tourism *value* of marine and coastal ecosystems. A detailed survey of individuals' preferences and *willingness-to-pay* for coastal environmental characteristics is needed to quantify this component of non-market tourism and recreation.

Aesthetic *value* also appears in the housing market. Individuals' housing decisions can reveal their preference for the aesthetic beauty of coastal areas through the difference between the amount they are willing to pay to live in coastal areas with the accepted amount to live in inland areas. The *Hedonic pricing method* is used to statistically analyse how the aesthetic *value* of coastal areas is embedded in the *value* of coastal property. This economic method requires substantial amounts of data about properties and their *rent*al and sales prices.

An example of the aesthetic *value* of coastal areas can be drawn from Guam, where the *value* of proximity to reefs for beachfront housing was estimated at US$ 10.9 million per year, based on a statistical analysis of a database listing 800 house sales from 2000 to 2004 (Van Beukering, *et al.*, 2007). Every additional kilometre a house was removed from the coast decreased its housing *value* by US$ 19,437. This *value* likely captures aesthetic *value*, shoreline protection and recreational *values* (Salcone, *et al.*, 2015).

6.9.7 Other Cultural and lifestyle values

The use of natural resources is often associated with a high level of cultural or passive *values*, which include spiritual and religious *values*, knowledge systems, educational *values*, inspiration, social relations, historical and heritage *values*. They also incorporate moral, recreational, aesthetic, traditional *values* and the *value* of a sense of place. A cultural connection to the ocean is fundamental to the people of Samoa, as noted in Samoa's national emblem, which has the Southern Cross, the sea and the coconut palm on the shield crowned by a Christian cross.

A range of traditions bind people to marine and coastal areas. For generations, Samoans have used marine resources in various ways, including traditional local foods, decoration for costumes and accessories, gifts, fishing methods and practices, myths and legends, traditional songs, building materials, and the practice of traditional marine resource management systems.

Despite modernisation and change, the Samoan way of life is still very much grounded in its traditional culture and belief systems. For example, the dominance of the communal system of social organisation where the social unit is the 'aiga' or the extended family, represented by a 'matai' or chief responsible for the use of land and other resources belonging to the group. Religion also plays an important role in the Samoan way of life (Bureau of Statistics, 2020). Against this backdrop of communal social organisation and the maritime geography of Samoa, the ocean plays a central role in the maintenance of the daily livelihoods of the majority of Samoans. Some of the different Samoan practices and traditions which have implications for maritime culture or involve marine areas with *economic value* to Samoans, are described below.

Governance and resource management –Samoan community-based marine resource management systems reflect cultural practices. The fish reserves, marine protected areas and marine reserves managed by local communities (MMAs), demonstrate the importance of local governance structure and the Samoan core *value*s founded upon Fa'a-Samoa. Samoans show respect to their local leaders such as 'matai' and church pastors and preachers by sharing their best fish catches. They also follow traditional fishing rules such as observing 'tapu' or taboo areas and banned fishing methods. and embrace practices to conserve and protect marine resources and avoid overexploitation. As well as contributing to maintaining social order and harmony, these practices are more effective than centrally managed fisheries' systems imposed by the government. They also have economic implications, such as reducing monitoring and enforcement costs.

Foods – Fish and marine seafoods are an integral part of the Samoan diet and culinary practices. Fish is central to the national dish 'oka', which is made from raw fish marinated in lemon juice and coconut cream. Fish is also an important component of the Samoan 'umu' which is prepared whenever a meal is required for a large group or extended family, as the traditional open oven or fire pit can cook large quantities of food at any one time.

Fishing practices – Palolo (a polychaete worm which is caught only during full-moon in October or November) continues to be a festive occasion where villages often harvest these worms as a group activity. The worms are harvested using lights and scoop nets, and participants have to enter the ocean in clean attire.

Song and dance – These are an integral part of Samoan culture. The 'siva' performed by women involves graceful movements that often tell stories about fishing experiences and life at sea, or other maritime tales.

Tattoo – (known as 'tatau') is a spiritual practice for Samoan men to demonstrate their strength and courage. The process is conducted by a master tattooist who uses handmade tools made from shark's teeth, bones, tasks and shells. Tattoo patterns are also often inspired by marine plants and animals.

Oral traditions, myths and legends – there is a rich oral tradition of Samoan storytelling as heard in the 'tala le vavau' (ancient stories translated as myths and legends) of Metotagivale and Alo, which highlights the core cultural *value*s that underscore Fa'a- Samoa of fanua or place (Lilomaiava, 2020). Language, proverbs, names and place names in Samoan oral tradition demonstrate the country's relationship with place and their ecological knowledge. The 'tala le vavau' transmits and reinforces conservation ethics and ecological perspectives (Lilomaiava, 2020), such as the 'tapu' placed by chiefs to protect nesting turtles.

Maritime cultural heritage – One of the roles of cultural heritage is to contribute to improving understanding of the past and the sustainability of rural and urban communities. Samoans were well-known for their canoe building and navigating skills, where they not only ventured out in deeper waters fishing for large tunas, but also transported goods and supplies for trade with neighbouring islands, guided by the wind, moon, and stars. With the advent of motorised vessels, such traditional skills are now on the brink of extinction. In response, the Samoan Voyaging Society has instigated a project to revive the heritage of traditional ocean voyaging, and to promote environmental stewardship to younger people; a purpose-built Samoan canoe, the 'Gaualofa', is used as a platform for raising awareness and motivation to revive traditional knowledge and skills. Simple dug-out canoes are still used in rural areas for subsistence fishing as shown in Figure 29.

Figure 29: Samoan traditional dug-out canoe used for subsistence fishing

Handicrafts – Samoans make traditional fine jewelry such as necklaces, bracelets, earrings and hair accessories from corals, pearl shells and other seashells. These products have a high cultural *value* as they symbolise traditional Samoan art and skills.

Exchange of gifts – Fa'alavelave is a ceremony incorporating a major exchange of gifts, such as at weddings and funerals. *Value* is derived through a sense of social status in the exchange process. An individual's contribution to the community is regarded as more important than the gifts they accumulate for themselves. It is expected that the host family offers more than it receives. High *value*d seafood, either bought or caught, is an integral part of this exchange process.

The cultural *value* of marine areas to Samoans is difficult to quantify, often because it does not involve direct or indirect monetary transactions. However, there is an associated *opportunity cost* when individuals invest time and sacrifice other activities, to maintain cultural practices and traditions, demonstrating the *economic value* of culture. These types of non-market benefits can only be quantified and monetised using sophisticated *Choice modelling* or *Contingent valuation* techniques, which were beyond the scope of this valuation study.

6.10 Existence and *bequest values*

Ecosystems can have *value* to people even if they do not directly receive benefits derived from the *ecosystem services*. Some people may place a *value* on marine resources independent of their present use. Individuals may simply appreciate knowing that ecosystems are healthy, and that species are not becoming extinct, such as the continued existence of whales as a charismatic species. This is the *existence value* of ecosystems.

Changes in the natural character of ecosystems affect the *values* that people perceive to be attached to the environment. Development and mitigation activities can either increase or decrease *existence values*. For example, creating a sanctuary for turtle breeding or enhancement of mangrove areas through replanting can increase their *existence value*, while reclamation of mangrove areas or changes to beaches near nesting sites may decrease the *values*. *Existence values* are measured in the context of an alternative state or plan such as 'with' or 'without' scenarios.

Some individuals may also want to maintain the option for future uses of the marine environment (*option value*). This is related to the potential use. Future resource use can have a high *value* if close substitutes are not present . Sometimes, *option value* can be construed as a type of insurance premium in case changes in future preferences and the ability to use for future benefit occurs, such as the case of seabed resources.

Pacific Island communities that own and live on ancestral land tend to have a strong sense of custodianship over their land and its resources (expressed by terms such as the 'vanua' or the 'fanua'). This may translate into an *economic value* for the present generations to pass on these ancestral lands to future generations. *Value* arises from a desire to bequeath the environmental resources or preserve ecosystems to ensure availability for future generations (*bequest value*). This practice is familiar to Samoans in their use of customary lands and marine areas.

The *existence value* of nature's ecosystems and the *value* of preserving nature for future generations (*bequest value*) are *non-use values*. In general, these *values* are not reflected in markets or national accounts i.e. they are not easily visible to decision-makers, which can lead to poor resource management decisions (Cesar, et al, 2003). Although difficult to measure, existence and *bequest values* are components of the *total economic value* of an ecosystem. The only way to estimate their *value* is to ask people their personal worth using stated preference techniques via economic surveys.

There are two main stated preference approaches. The process of asking individuals what they would be willing to pay for the presence or maintenance of an environmental attribute such as an *ecosystem*, is known as *contingent valuation* and involves a sequence of yes/no questions to identify the respondent's maximum *willingness to pay* for the entity in question. The second method, *Choice modelling*, involves asking respondents to make hypothetical trade-offs between different bundles of attributes, which may include different levels and combinations of environmental resources, including *ecosystem services*. Both methods use detailed surveys or interviews, requiring individuals to state their preference for the non-market *ecosystem* service either in monetary terms, or in terms of willingness-to-trade other goods or services for the non-market *ecosystem* service in question.

A single individual may be willing to pay a very small amount for the existence of, or option for future use, of a resource, but the sum of *willingness-to-pay* across many thousands of individuals may still represent considerable *economic value* (Loomis, *et al.*, 2000; Carson, *et al.*, 2003). An example of this is a *contingent valuation* study from Fiji, which estimated the *bequest value* local users were *willing to pay* to ensure availability of their traditional fishing grounds on the Coral Coast for future generations to use (O'Garra, 2009). The study, using monetary as well as time-based contributions, estimated *bequest values* as between FJ$1.25 -FJ$1.41 (US$0.65 – US$0.73) per individual per week, or FJ$183.90 (US$106.91) per household per year. This represented a significant proportion of the stated average household expenditure, comparable to spend on durable household goods, clothes and footwear. The results of the study suggest that low-income groups may hold significant *bequest values* for certain goods and services, which should be included in economic *valuation* studies (O'Garra, 2009).

A similar example originates from Madagascar, where a study showed that *bequest values* relating to ecosystems can be significant for indigenous communities whose livelihoods and cultures are intrinsically connected to nature (Oleson, *et al.*, 2015). The study used a discrete choice experiment to determine Indigenous fishers' preferences, and willingness to pay, for preserving resources for future generations as gains from management actions in a locally managed marine area. The study revealed that respondents were willing to pay a substantial portion of their income to protect ecosystems for future generations, even where they were forced to make trade-offs among other livelihoods supported by *ecosystem services* (Oleson, *et al.*, 2015). Due to pandemic related restrictions, conducting case studies using stated preference surveys to elicit data about these non-market benefits of marine and coastal ecosystems in Samoa, was not possible.

6.11 Supporting services: ecological processes and biological diversity

As the integrity of the *ecosystem* underpins the generation of services, any modifications to the ecological structure and systems can thus affect the capacity of the *ecosystem* to supply *ecosystem services* (Culhane, *et al.*, 2018). Some *ecosystem functions* do not directly benefit individuals but are instrumental in supporting other *ecosystem functions*. Basic *ecosystem functions* such as photosynthesis, nutrient cycling, soil and sand formation, can be seen as intermediate services which provide inputs to many human activities. The ocean plays an important role in the production of oxygen (phytoplankton produce half of the earth's oxygen), nitrogen fixation, waste assimilation and regulating global temperatures and climate (Samonte-Tan, *et al.*, 2010; Galland, *et al.*, 2012).

While some of these *ecosystem functions* may not benefit individuals directly, they underpin life on earth. None of the *values* identified and discussed in this study can exist without well-functioning ecological processes (such as production, growth, recruitment), underpinned by the biological and abiotic diversity of marine ecosystems (MEA, 2005). Their *value*, however, is often carried over into direct or final *ecosystem services*. To avoid double counting the *value* of supporting *ecosystem services*, *ecosystem service valuation* should focus on the final human benefits resulting from the end products of *ecosystem functions* (Fisher, *et al.*, 2009; Boyd & Banzhaf, 2007). In so much as these *supporting services* facilitate more tangible *ecosystem services*, their *value* is captured in the *valuation* of these services; to *value* them separately from the end user *values* would lead to double counting.

6.12 Summary of *values*

The *economic values* of the *ecosystem services* estimated in this study are summarized in Table 41, while Figure 30 shows the average annual estimated *values* for the different *ecosystem services*. The total annual *value* of marine and coastal *ecosystem services* in Samoa in 2019 is estimated to be just over SAT$ 372 million or US$141.5 million as shown in Figure 1 and Table 1 in the executive summary.

Table 41: Annual *economic value* of marine and coastal *ecosystem services* in Samoa in 2019 prices

Sector	Ecosystem service benefits	Beneficiaries	Net annual value 2019 adjusted (million)	Sustainability[1]
Fisheries	Subsistence fishing	Samoan households, particularly low income	SAT$48.13 m – SAT$52.35 m US$18.30 m – US$19.90 m	Inshore habitat can support sustainable subsistence harvest but areas of localised overfishing has reduced productivity, thus threatening sustainability
	Domestic coastal fishing	Samoan fishers and consumers, some restaurants and businesses (only value to fishers is estimated)	SAT$50 m – SAT$54.4 m US$19.01 m – US$20.68 m	Data trends indicate some overfishing
	Sea Cucumber	Some local fishers and consumers	SAT$139,165 US$52,914.45	Some recovery of stock because of moratorium; decline of targeted species; re-stocking trials could further enhance productivity
	Deepwater bottom fishing	Some local fishers, consumers, and some restaurants, some overseas relatives	SAT$207,928 US$79,060.08	Current stock is sustainable but will require management of catch and effort
	Offshore tuna	Local businesses, some fishers, foreign fishing fleets, government, some local processing and fishing jobs (value is government revenue and industry net economic benefit).	SAT$7.78 m – SAT$10.23 m US$2.96 m -US$3.89 m	Current albacore longline fishing and skipjack is sustainable but yellowfin and bigeye will require adopting regional management measures for catch and effort
	Nearshore pelagic troll fishing	Some local fishers, consumers, some restaurants	SAT$1.53 m US$581,749.04	Catch rates variable and dependent on access to FADs; skipjack stock is sustainable
	Marine Aquarium	Some tourists and local Samoans benefit since no commercial harvesting is undertaken	NA	Potential for mariculture could be explored; harvest from wild stock is unsustainable
	Mariculture	Fisheries Division through capacity building	NA	Still at an experimental level
Mining	Sand & aggregate	Local business operations, individuals and communities who extract; government revenue through charges	SAT$26,430[2] US$10,049.43	Unsustainable local areas of extraction, causing erosion; can impact on tourism and fisheries; require effective management measures
	Deep-sea minerals	With no activity in the deep sea, the tourists and fishers are major beneficiaries	NA	Limited understanding of the ecosystem potential and threats; requires institutional arrangements to be established for further research and investigations

Tourism	International tourism	Local Samoan and foreign businesses, tourists, local communities as input suppliers, government through taxes and charges	SAT$76.09 m – SAT$222.34 m US$28.93 m – US$84.54 m	Tourism can be sustainable if managed under an integrated ecosystem-based approach
	Domestic tourism	Some Samoan businesses and individuals as consumers, government	SAT$29.7 m US$11.29 m	Can be sustainable with a management plan; requires more detailed study including its cultural value assessment
Regulating services	Coastal protection	Samoans and visitors, in particular owners of coastal properties (avoided repair costs)	SAT$7.5 m - SAT$19.8 m US$2.85 m -US$7.53 m	This could be either increased or decreased depending on efforts to restore degraded ecosystems and protecting reefs and beaches
	Carbon sequest-ration	Global benefit; potential benefit from carbon credits (not included in the value)	SAT$146,084[3] US$55,545	Mangrove protection strategies will be needed
Foreign aid and investment	Research, education and management	Mostly government; aid money trickles through the economy to organisations, consultants, businesses, students and researchers. (values reflect cash grants to marine and coastal projects including those associated with climate change adaptation)	SAT$65.76 m[4] US$25 m	Depends on international relations and agreements related to nature conservation

NA Not available
1 Sustainability refers to whether the values presented can be expected to increase, stay the same or decrease (unsustainable) with current human behaviours
2 Gross value
3 Social benefit of carbon sequestration from mangroves; market value is estimated as (SAT$ 74,076 -SAT$ 99,219/yr)
4 Cash grants to marine, coastal and climate change related projects

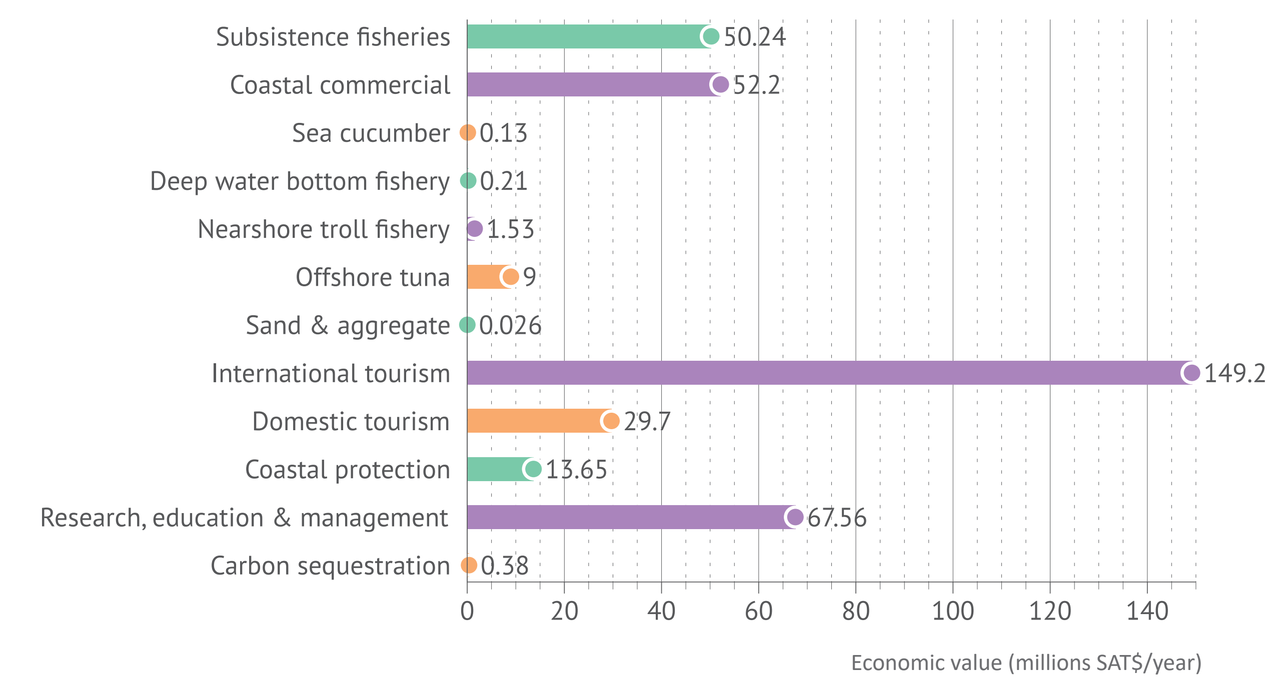


Figure 30: ***Economic value*** **of marine and coastal ecosystem services in Samoa in 2019**

7. Summary and discussion

The information in Chapter 6 allows understanding of the human benefits derived from Samoa's marine and coastal environment. The information can, and should be used to compare the types, magnitude, and distribution of benefits from different marine resources. For example, the subsistence fishery, coastal commercial fisheries, and the tuna fishery are services of comparable orders of magnitude (between SAT$ 2.96 million and SAT$ 54.4 million annually), but the benefits accrue to different groups of people. Information about the distribution of the benefits obtained from different ecosystems can help decision-makers distinguish those who will benefit or suffer from a change in resource management policies and programmes.

This data can also help decision-makers design incentives to enhance management practices and to prioritise the allocation of government resources. For example, commercial tuna fisheries do not benefit average households in Samoa, but they do generate *revenue* for government operations. Therefore, the government has an incentive to manage the tuna industry to gain that *revenue*, even though the impact on Samoan households is more ambiguous.

Even though Samoa's EEZ is the smallest among Pacific nations, it is still 40 times larger than its land area and not only supports fisheries, but also acts as the backbone of Samoa's economy i.e. its tourism industry. Marine and coastal *ecosystem services* in Samoa can be seen as the equivalent of a bank account of natural capital wealth. Some withdrawals from this account have been unsustainable (such as the extraction of coastal sand and aggregate and the sea cucumber fishery), while other services associated with tourism could provide much greater human benefits without depleting the nation's stock of natural capital.

The *values* presented in Chapter 6 for fisheries and tourism mostly represent benefits to producers, i.e. those who harvest, extract, or earn *revenue* from a resource. Coastal protection *values* represent benefits to all residents and visitors, and carbon sequestration *values* are benefits to the whole world. Government benefits are included where they are significant. Government *revenue* from taxes or fees from Samoan businesses and residents represent a redistribution (or transfer) of benefits within Samoa and are not a true *economic value*.

In contrast, benefits accrue to Samoans when tax or fees are derived from foreign visitors or foreign businesses. However, the costs to administer and collect fees must be subtracted from *gross revenue*. The administrative costs related to licensing and collecting fees have not been estimated in this study nor have they been subtracted from sand mining *revenue*, fisheries licensing *revenue*, tourism tax *revenue*, or processing aid and grant monies. Consumer benefits have not been estimated for fishing and tourism, apart from subsistence fishing, where the producers and consumers are the same individuals. The greatest consumer benefits in Samoa are obtained from the inshore fishery, where almost 100% of the catch is consumed by Samoans.

The *ecosystem* service of subsistence fishing provides benefits to many Samoan households in rural and urban areas. However, it is very difficult to measure and monitor the harvest and fishing pressure on this *ecosystem* service as the haul of many fishers is for household consumption, as well as some surplus catch for sale. Current household income and expenditure survey data (HIES) have been used to extrapolate harvest estimates, although the CPUE measurements provide more detailed local assessments and are the best indicators of fishing pressures. The variability of information obtained from different sources of data has made quantifying this *ecosystem* service difficult.

It may be more appropriate to *value* artisanal fishing as a whole, whereby small-scale fishing for home consumption and for sale are valued together, as they depend equally on the productivity of inshore habitat. This could require a detailed socio-economic survey, including a creel survey, and an assessment of CPUE, consumption patterns and costs and *revenue*. The combined harvest *value* of SAT$ 130.5 million or US$ 49.6 million, is a conservative estimate of the annual *value* of Samoa's inshore subsistence and domestic commercial fisheries from an estimated annual harvest of between 10,000 and 10,438 tonnes per year. This converts to between 20.4 tonnes and 21.3 tonnes per km^2 of reef area as habitat. It is most likely that areas of high fishing pressure exist that may not be sustainable in the longer term.

The sea cucumber fishery has not fully recovered from earlier overfishing, although subsistence harvesting is allowed, given the cultural significance of the commodity. The viscera of sea cucumber are sold as 'processed food', while the fresh products are categorised as 'echinoderms', thus there is no dis-aggregated information on current levels of harvest. Concern about the potential continuation of illegal trade remains present. Updating data on local production and sale will also benefit ongoing re-stocking projects.

Commercial fishing also includes deepwater bottom fishing and small-scale tuna trolling as well as the oceanic tuna fishery. The offshore tuna fishery is aimed at export markets, while the inshore artisanal fishing for finfish and invertebrates, is sold in local markets. It is difficult to determine from available records the amount of tuna from small-scale trolling and deepwater bottom fish enters the export market. Although Samoans are employed in commercial fisheries, the large-scale tuna fishery is dominated by foreign vessels. Those tuna vessels, which unload their catch in Apia provide some local employment and *revenue* to the government.

Current levels of harvest from the deepwater bottom fishery for demersal fish suggest the fishery is likely to be in a healthy state. An effective management plan for the fishery would mitigate the risk caused by the slow-growing and aggregating nature of the stock prone to overfishing within a short time period. The troll fishery in Samoa alternates between longline and bottom fishing, therefore it is difficult to determine the actual level of fishing effort dedicated to this fishery, which may also fluctuate with seasons and the market price of various species of tuna and non-tuna species.

The Government of Samoa receives benefits from license and access fees from foreign vessels that fish in Samoan waters. The annual access and license fees have been estimated to be about US$1 million, while employment of Samoans was also estimated to be about US$1.1 million, which benefits Samoan households, while local purchases of US$1.05 million benefit local industries for input supplies. Fishing cost data have been derived from FFA estimates of *value-added* ratios, rather than from an assessment of actual variable costs.

Samoa has the advantage of being close to American Samoa, which is the main market for its albacore tuna. Available data suggest scope for further expansion of the albacore fishery based on the effective implementation of the National Tuna Management Plan, even though the Samoan fishery does not contribute significantly to the overall regional impact on the tuna stock. However, the government needs to support regional measures to maintain current spawning biomass levels (Secretariat of the Pacific Community, 2018). Local fishers and consumers also benefit from the troll fishery for small-scale pelagics. With careful deployment of FADs, further expansion of the skipjack fishery in Samoa could optimise the benefits from this *ecosystem* service.

Dredging of coastal sand and aggregate for commercial purposes provides benefits to the companies involved and the individuals and community groups who extract and use these resources for construction. The negative impacts of extraction and dredging could not be assessed in this study. Probable impacts include destruction and siltation of reef and lagoon habitats, which may harm Samoa's largest domestic marine *ecosystem* services, such as inshore fisheries and tourism. Beach mining for domestic purposes provides minimal benefits to the government, but real benefits to Samoan households could not be quantified without a robust survey. The erosion impacts of beach sand mining and lagoon dredging are potentially damaging and warrant hydrogeological assessment.

Although deep-sea exploration and mining operations are not currently operating in Samoa, earlier studies have generated government awareness of the country's mineral resource potential. Furthermore, given the transboundary nature of this *ecosystem* service, the government can stay informed of emerging developments in the region. However, adequate environmental safeguards will need to be developed to ensure the fisheries and tourism sector do not adversely impact tuna and deep-sea bottom fish habitats. such as from threats to whale migration.

Export *revenue* from international tourism in Samoa was 22% of GDP in 2019 – tourism remains the largest exporter. The Samoan Tourism Authority markets its tourism products and services as a blend of traditional Samoan culture, and a pristine natural environment, complemented by its attraction as a tropical island (Ministry of Natural Resources and Environment, 2015). This marketing strategy places a heavy reliance on the marine and coastal zone to support such expectations and aspirations.

It is estimated that the coastal and marine ecosystems contribute SAT$109.5 - SAT$348.9 million in annual *economic activity* in Samoa, with a minimum estimate of the *net value* of those expenditures (44.5%) as SAT$48.72 - SAT$155.25 million each year. Tourism benefits a variety of businesses and their employees, while also providing government tax *revenue*. Tourism related *ecosystem services* can be sustainable if managed and regulated effectively. Destructive types of coastal fishing and nearshore sand and aggregate mining could negatively impact tourism.

Reefs, mangroves, and seagrasses protect Samoa's coasts from erosion and flooding. The *value* of this coastal protection *ecosystem* service is the avoided cost of damage that would otherwise occur. Given that the majority of Samoans live close to the coast, commercial and residential properties are exposed to coastal processes; thus, avoided costs can be significant. The annual damage cost to coastal residential and tourist accommodation from storm flooding avoided by the presence of coral reefs, was estimated to be about US$7,535,962 or SAT$19,766,828. In comparison, the construction of man-made structures for storm mitigation, to compensate for the absence of these *ecosystem services*, would likely result in much higher costs.

In addition to erosion protection for fish and invertebrate habitat, the 374 ha of mangroves in Samoa potentially provide carbon sequestration benefits to the global community worth about US$146,084 per year. In principle, the protection of mangroves areas at risk of destruction could be marketed and sold as carbon offsets. However, the costs of verifying and managing these protected areas would need to be assessed. Given the small size of Samoa's mangroves and the current low world market price of carbon, this benefit may be relatively small. However, the real cumulative benefits of avoiding mangrove destruction are much higher for Samoa given the fragile nature of its habitat.

Marine and coastal areas attract foreign aid for research, development and management work that benefits Samoa's government and the country's inhabitants. In 2019/20, 28.6% of total donor cash grants were allocated to coastal and marine, and climate change-related projects worth about SAT$ 65.8 million or US$24.8 million. Investment in marine and coastal biodiversity also includes many projects coordinated through MNRE, Fisheries Division and NGOs, so total benefits will be much greater. Money spent by individuals and institutions which conduct research on marine and coastal ecosystems or advocate for their protection, also benefits the government, while aid expenditure trickles through many sectors of the economy, much like tourism expenditure.

Other marine and coastal *ecosystem services* include mariculture, handicrafts, bioremediation, cultural identity, and aesthetic beauty. Although these services have not been quantified in this study due to the lack of data and resources, they provide important passive benefits to Samoa and the rest of the world.

A cultural connection to the ocean is fundamental to the people of Samoa, with the sea being one of the features of the country's national emblem. The Samoan way of life is still very much grounded in its traditional culture and belief systems, which dictate how people interact with each other and practice resource management. While the cultural *value* of marine areas to Samoans is difficult to quantify, there is an *opportunity cost* associated with it, as seen when individuals invest time and sacrifice other activities to practice or maintain their cultural practices and traditions. In doing so, they are demonstrating the *economic value* of culture. Capturing these *value*s through a more detailed assessment would certainly help justify government expenditure on incentives to improve resource management and stewardship.

8 Recommendations and future directions

This report should be considered as the first step towards a more complete and robust *ecosystem services valuation* for Samoa. The study objectives were to use existing data and identify data gaps that could be addressed in future projects or studies. The project's large scope (national *valuation* of many services) has prevented detailed topic analysis. Each subsection in Chapter 6 should serve as a basis for information about the different *ecosystem services* that the Samoan government can choose to investigate more deeply as the need arises.

Problematic data gaps are discussed in the 'Quantify' section for each *ecosystem* service. If the Samoan government decides to use economic information about *ecosystem* service benefits, the gaps in data should first be *evaluated* to enable a more rigorous assessment of benefits.

This study is an effort towards a national process of recognizing the human benefits of natural ecosystems. Further *valuation* of *ecosystem services* should be targeted to address the specific application to many uses highlighted in this report, leading to more equitable and sustainable management of Samoa's marine assets. More generally, the Samoan government should continue to progress towards accounting for natural capital to ensure the country's sustainable prosperity. Several initiatives are already underway which require incorporating *ecosystem service valuation* into national accounts and reporting systems, such as work related to the Convention on Biological Diversity Aichi Target 2; the Wealth Accounting and Valuation of Ecosystem Services;[40] the Ocean Health Index, and the UN System of Environmental Economic Accounting SEEA - Ocean Accounts. In addition, this study can be a useful resource for moving forward with the Blue Pacific Ocean

40 A world Bank-led initiative to prioritise sustainable development by mainstreaming natural resource accounting into national accounts and national development planning.

Agenda for Samoa under the Pacific Islands Regional Ocean Policy.

Although more detailed assessments of the *value* of *ecosystem services* will be required, this report could serve as a *baseline* for natural capital accounting. In addition, the data gaps also illustrate that more research is needed in assessing the environmental carrying capacity of Samoa's marine environment to continue the provision of *ecosystem services*. This will support controlled development and implementation of policies by planners and policy makers for sustainable resource use.

Quantifying the monetary *values* of *ecosystem services* can help government departments, NGOs, the private sector, and communities assess the trade-offs and synergies inherent in an integrated approach for coastal and marine ecosystem-based management. An economic *valuation* can improve the decisions made by policy makers, environmental managers and planners, by providing information about the social benefits and costs associated with alternative coastal and marine policies. This information can help ensure the decisions are socially acceptable, economically efficient, and environmentally sustainable.

Currently, the Bureau of Statistics collects data from the National Census, Household Agricultural Survey, and Household Income and Expenditure Survey, which provide detailed estimates of several socio-economic variables. These surveys could be strengthened to collect more robust data on environmental use matters, which can contribute to valuing *ecosystem services*. This activity will require a more coordinated effort between the departments involved to formulate and administer an integrated approach to data collection compared to the present compartmentalised approach, which is prone to duplication and incompatibility. Inter-agency cooperation to develop new approaches for the collection of data on the extent, condition, and *economic value* of Samoa's *ecosystem services* can help the Samoan economy transition to an ecosystem-based management approach.

Samoan households are highly dependent on coastal fisheries for food and income and the government benefits from license and access *revenue* from tuna. While information on tuna catches and effort are available, data is limited on the economic aspects of the industry, such as fishing costs and local market information on tuna catch from trolling. This information is important for determining the net benefits from this *ecosystem service*. More resources need to be allocated to support the timely collection of coastal fisheries data to improve understanding of production and consumption trends, and the ecological status of the ecosystems which provide the *ecosystem* benefits, such as fish and invertebrates.

The recreational opportunities offered by coastal and marine ecosystems are at the core of Samoa's tourism service products. Maintaining the environmental quality of assets such as clean beaches and healthy coral reefs is essential. The costs and benefits of sand and aggregate mining need to be thoroughly *evaluated* by considering their potential effects on fishing and tourism *ecosystem services*. In addition, a visitor survey to assess the consumer benefits of the various marine-based ecosystem services can be helpful to determine tourists' willingness to support marine conservation activities.

Lack of knowledge about the deep-sea environment and scientific uncertainty about trends in its health, pose a major challenge for assigning *economic values* to deep-sea *ecosystem services* and biodiversity. Growing concern regarding the lack of knowledge about deep-sea ecology and habitats, and Samoa's dependence on marine-based tourism and fisheries, would seem to justify support for a moratorium on deep sea mining. Strengthening the institutional and regulatory framework for mining would be a necessary first step in the short-term.

Non-market values linked to tradition, culture and heritage are an important aspect of the Samoan way of life. Although these *values* were not quantified in this study, their qualitative characteristics indicate their critical role in improving the livelihoods of Samoans by encouraging resource stewardship. More in-depth research is needed to identify non-market cultural *values* such as the *bequest value* of traditional resource management practices by identifying their *opportunity costs* and individuals' willingness to pay (WTP) for their continued existence.

Advocacy programmes that increase public awareness and understanding of the importance of ecosystems are needed to promote responsible stewardship of *ecosystem services* in Samoa. This report can complement the information available to NGOs and other civil society groups, such as schools and churches, to communicate the importance of ecosystems and biodiversity to society. Quantifying the benefits from Samoa's marine ecosystems presents a strong argument for more sustainable use of the ocean and its resources.

Overall, the report highlights that ecosystem services are indeed the foundations of our economies. Through their provisioning services, they supply food and medicines, while the cultural services support our social and emotional sustenance. The regulating and maintenance services, through nature's processes, help maintain the hydrological cycle, regulate climate, filter pollutants, and assimilate waste, without which life would not be possible.

Given such a backdrop, this report reinforces the need for nature-based solutions to address societal challenges such as climate change, food security and natural disasters. Implementing approaches that include ecological restoration, ecosystem-based adaptation, ecosystem-based mitigation, ecosystem-based disaster risk reduction and area-based conservation, such as marine protected areas, provide alternative policy options that cost effectively support biodiversity.

A significant limitation of this work is the lack of scenario analysis. *Ecosystem services* are *value*d according to their current use, ideally by applying data from 2018-2019 or averages from the past five to ten years, which does not describe the potential *value* of the ecosystem. Scenario analysis however, considers different options for resource use and management, quantifying the *ecosystem services* that people would receive under different scenarios. This is a type of *cost benefit analysis*, whereby the *value*s of *ecosystem services* are used to quantify the costs and benefits of changes to ecosystems. This report could be used as a starting point for these types of analyses.

9. Caveats and considerations

The significance of the qualitative and quantitative information presented in Chapter 6 can be compromised by the need to provide a simple and brief summary. The demands placed on political leaders necessitates clear and concise summaries of research, but the oversimplification of *ecosystem* service research can lead to misinterpretation and inappropriate generalisation of the results. The benefits which have been quantified and *value*d above should be considered individually. Policymakers must resist the urge to aggregate these *values* for the following reasons:

Each *value* represents a slightly different type of benefit. *Gross values*, *net values*, employment, government *revenue* and *consumer surplus* are all units for measuring benefits but should not be combined, despite being all represented in Samoan (SAT$);

Values represent current use, not sustainable use, equitable use, or maximum potential benefit. Some *ecosystem services* may be unsustainable at current rates of exploitation, while others may support greater expansion; and

Some *ecosystem services* complement each other, while others compete. For example, the development of the aquarium trade may adversely impact the inshore finfish and invertebrate fishery, whereas protection of mangrove areas may increase coastal protection, increase carbon sequestration, and increase inshore fisheries productivity.

The above three qualifications must be considered whenever the results are used, reproduced, or updated.

The *valuation* results in Chapter 6 mainly measure *producer surplus* derived from each *ecosystem* service, and therefore only a partial measure of the full contribution ecosystems make to human well-being. The full *economic value* includes benefits to consumers, producers, and government as well as market and non-*market values* (i.e. *direct use value*, *indirect use value* and existence). In practice, full *economic value* is nearly impossible to calculate because the data required is rarely available.

The information presented in this study can assist practical decision making about marine and coastal *ecosystem services* and even though the information on annual *values* has a short-term focus, it is still applicable to many decision contexts.

Many business activities, development projects and political decisions are made on an annual or, at most, decadal basis, and so annualised *values* allow for convenient comparison (Salcone, *et al.*, 2016). Annualized *values* are useful to highlight ecosystems' *real economic value*, and provide tangible, quantifiable benefits to humans. They should therefore be managed and protected in ways that can maximise human *welfare* for current and future generations.

Another important consideration is the relationship between *ecosystem* service *values* and human population density. *Ecosystem* service *value* is directly correlated to the number of people who receive benefits. Healthy, intact ecosystems often exist where there are few people. No matter how productive the ecosystem, the *values* of *ecosystem services* in remote places are often quite low because so few humans receive the benefits of the *ecosystem functions*.

Higher density populated areas may have greater *ecosystem* service *values* as more benefits of *ecosystem functions* are captured by humans. Due to this phenomenon, it is very important to analyse the ecological sustainability of current resource use in assessing whether the status-quo *values* can be maintained, or if they are likely to decrease over time. Reference to the 'Quantify' and 'Uncertainty' sections in Chapter 6 is recommended for specific qualifications regarding each *ecosystem service valuation*. This is important for a clear understanding of the meaning and limitations of the *values* obtained in this analysis.

10. Glossary

A *Avoided damage cost valuation method*: A cost-based *valuation* technique that estimates the *value* of an *ecosystem* service by calculating the damage that is avoided to infrastructure, property and people by the presence of ecosystems.

B *Baseline*: The starting point from which the impact of a policy or investment is assessed. In the context of *ecosystem service valuation*, the *baseline* is a description of the level of *ecosystem* service provision before a policy or investment intervention.

Beneficiary: A person that benefits from the provision of *ecosystem* system services.

Bequest value: the *value* to the current generation of knowing that something (e.g. pristine coral reef) will be available to future generations.

C *Choice modelling*: *Choice modelling* attempts to model the decision process of an individual or segment in a particular context. *Choice modelling* may be used to estimate non-market environmental benefits and costs. It involves asking individuals to make hypothetical trade-offs between different *ecosystem services*.

Constant prices: Prices that have been adjusted to the price level in a specific year. *Constant prices* account for *inflation* and allow *values* to be compared across different time periods.

Consumer surplus: The difference between what consumers are willing to pay for a good and its price. *Consumer surplus* is a measure of the benefit that consumers derive from the consumption of a good or service over and above the price they have paid for it.

Contingent valuation: *Contingent valuation* is a survey-based economic technique for the *valuation* of non-market resources, such as environmental preservation or the impact of contamination. It involves determining the *value* of an *ecosystem* service by asking what individuals would be willing to pay for its presence or maintenance.

Cost benefit analysis: An *evaluation* method that assesses the economic efficiency of policies, projects or investments by comparing their costs and benefits in *present value* terms. This type of analysis may include both market and non-*market values* and accounts for *opportunity costs*.

D *Direct use value*: The *value* derived from direct use of an ecosystem, including provisioning and recreational *ecosystem services*. Use can be consumptive (e.g. fish for food) or non-consumptive (e.g viewing reef fish).

Discount rate: The rate used to determine the *present value* of a stream of future costs and benefits. The *discount rate* reflects individuals' or society's time preference and/or the productive use of capital.

Discounting: The process of calculating the *present value* of a stream of *future values* (benefits or costs). *Discounting* reflects individuals' or society's time preference and/or the productive use of capital. The formula for *discounting* or calculating *present value* is: *present value* = *future value*/$(1+r)^n$, where r is the *discount rate* and n is the number of years in the future in which the cost or benefit occurs.

E *Economic activity analysis*: An analysis that tracks the flow of dollars spent within a region (*market values*). Both *economic impact* and *economic contribution* analysis are types of *economic activity analysis*.

Economic activity: The production and consumption of goods and services. *Economic activity* is conventionally measured in monetary terms as the amount of money spent or earned and may include 'multiplier effects' of input costs and wages.

Economic benefit: the net increase in social *welfare*. *Economic benefit*s include both market and non-*market value*s, producer and consumer benefits. *Economic benefit* refers to a positive change in human wellbeing.

Economic contribution: The gross change in *economic activity* associated with an industry, event, or policy in an existing regional economy.

Economic cost: A negative change in human wellbeing.

Economic impact: The net changes in new *economic activity* associated with an industry, event, or policy in an existing regional economy. It may be positive or negative.

Economic value: i) The monetary measure of the wellbeing associated with the production and consumption of goods and services, including *ecosystem services*. *Economic value* consists of producer and *consumer surplus* and is usually described in monetary terms. Or ii) The contribution of an action or object to human wellbeing (social *welfare*).

Ecosystem contribution factor: The degree of association between marine and coastal ecosystems and differ*ent* tourist activities.

Ecosystem functions: The biological, geochemical and physical processes and components that occur within an ecosystem.

Ecosystem service approach: A framework for analysing how human *welfare* is affected by the condition of the natural environment.

Ecosystem service valuation: Calculation, scientific and mathematical, of the net human benefits of an *ecosystem* service, usually in monetary units.

Ecosystem services: The benefits that ecosystems provide to people. This includes services (e.g. coastal protection) and goods (e.g. fish).

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Evaluate: To assess the overall effect of a policy or investment.

Evaluation: The assessment of the overall impact of a policy or investment. *Evaluation*s can be conducted before or after implementation of a policy or investment.

Existence value: The *value* that people attach to the continued existence of an *ecosystem* good or service, unrelated to any cur*rent* or potential future use.

F

Factor cost: Total cost of all factors of production consumed or used in producing a good or service.

Financial benefit: A receipt of money to a government, firm, household or individual.

Financial cost: A debit of money from a government, firm, household or individual.

Free-on-board: The taxable *value* for each fished species. This *value* theoretically represents the *market value* of the product, although this is not always the case in practice.

Future value: A *value* that occurs in future time periods. See also *present value*.

G *Geographic Information Systems (GIS):* An information system that captures, stores, manages, analyses and presents data that is linked to a geographic location.

Green accounting: The inclusion of information on environmental goods and services and/or natural capital in national, sectoral or business accounts.

Gross revenue: Money income that a firm receives from the sale of goods or services without deduction of the costs of producing those goods or services. *Gross revenue* from the sale of a good or service is computed as the price of the good (or service) multiplied by the quantity sold.

Gross value: The total amount made as a result of an activity.

H *Hedonic pricing method*: A method for pricing *ecosystem services*. Hedonic price models assume that the price of a product reflects embodied characteristics *value*d by some implicit or shadow price.

I *Indirect use value*: The *value* of ecosystem services that contribute to human *welfare* without direct contact with the elements of the ecosystem, for example, *regulating services* such as plants producing oxygen or coral reefs providing coastal protection.

Inflation: A general rise in prices in an economy.

Instrumental value: The importance of something as a means to provide something else that is of *value*. For example, a coral reef may have *instrumental value* in reducing risk to human life from extreme storm events.

Intermediate costs: The costs of inputs or intermediate goods that are used in the production of final consumption goods. For example, the cost of fishing gear used to catch fish is an intermediate cost to the harvest and sale of fish.

Intrinsic value: The *value* of something in and for itself, irrespective of its utility to something or someone else. Not related to human interests and therefore cannot be measured with economic methods.

M *Marginal value*: The incremental change in *value* of an *ecosystem* service resulting from an incremental change (one additional unit) in the quantity produced or consumed.

Market value: The amount for which a good or service can be sold in a given market.

N *Negative externality*: Negative externalities occur when the consumption or production of a good causes a harmful effect to a third party.

Net revenue: Monetary income (*revenue*) that a firm receives from the sale of goods and services with deduction of the costs of producing those goods and services. *Net revenue* from the sale of a good is computed as the price of the good multiplied by the quantity sold, minus the cost of production.

Net value: The *value* remaining after all deductions have been made.

Norminal: The term '*norminal*' indicates that a reported *value* includes the effect of *inflation*. Prices, *values*, *revenues* etc. reported in '*norminal*' terms cannot be compared directly across diff*erent* time periods. See also *real* and *Constant prices*.

Non-use value: The *value* that people gain from an *ecosystem* that is not based on the direct or indirect use of the resource. *Non-use values* may include *existence values*, *bequest values* and altruistic *values*.

O *Opportunity cost*: The *value* to the economy of a good, service or resource in its next best alternative use.

Option value: The premium placed on maintaining environmental or natural resources for possible future uses, over and above the direct or indirect *value* of these uses.

P *Present value*: A *value* that occurs in the present time period. *Present values* for costs and benefits that occur in the future can be computed through the process of *discounting* (see *discount rate*). Expressing all *values* (present and future) in *present value* terms allows them to be directly compared by accounting for society's time preferences.

Producer surplus: The amount that producers benefit by selling at a market price that is higher than the minimum price that they would be willing to sell for. *Producer surplus* is computed as the difference between the cost of production and the market price. *Value-added*, *profit*, and *producer surplus* are similar measures of the net benefit to producers. Although they differ slightly, the terms are used synonymously for this report to represent *economic value*.

Profit: The difference between the *revenue* received by a firm and the costs incurred in the production of goods and services. *Value* added, *profit* and *producer surplus* are similar measures of the net benefit to producers. Although they differ slightly, the terms are used synonymously for this report to represent *economic value*.

Purchasing power parity adjusted to exchange rate: An exchange rate that equalises the purchasing power of two currencies in their home countries for a given basket of goods.

Purchasing power parity: An indicator of price level differences across countries. Figures represented in *purchasing power parity* represent the relative purchasing power of money in the given country, accounting for variance in the price of goods. Typically presented relative to the purchasing power of US dollars in the United States.

R *Real*: The term '*real*' indicates what a reported *value* excludes or controls for the effect of *inflation* (synonymous with *Constant prices*). Reporting prices, *values*, *revenues* etc. in '*real*' terms allows them to be compared directly across diff*erent* time periods. See also *norminal* and *Constant prices*.

Regulating services: A category of *ecosystem services* that refers to the benefits obtained from the regulation of *ecosystem* processes. Examples include water flow regulation, carbon sequestration and nutrient cycling.

Rent: Any payment for a factor of production in excess of the amount needed to bring that factor into production (see also *producer surplus* and *resource rent*).

Replacement cost method: A *valuation* technique that estimates the *value* of an *ecosystem* service by calculating the cost of human-constructed infrastructure that would provide the same or similar service to the natural ecosystem. Common examples are sea walls and wastewater treatment plants that provide similar services to reefs, mangroves, and wetland ecosystems.

Resource rent: The difference between the total *revenue* generated from the extraction of a natural resource and all costs incurred during the extraction process (see also *producer surplus*). Refers to *profit* obtained by individuals or firms because they have unique access to a natural resource.

Revenue: Money income that a firm receives from the sale of goods and services (often used synonymously with *gross revenue*).

S *Social cost of carbon*: The *social cost of carbon* is an estimate of the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one tonne, in a given year. This dollar figure also represents the *value* of damages avoided for a small emission reduction (i.e. the benefit of a CO2 reduction).

Stated preference survey method: A survey method for *valuation* of non-market resources in which respondents are asked how much they would be willing to pay (or willing to accept) to maintain the existence of (or be compensated for the loss of) an environmental feature such as biodiversity.

Supporting services: A category of *ecosystem services* that are necessary for the production of all other *ecosystem services*. Examples include nutrient cycling, soil formation and primary production (photosynthesis).

T *Total economic value*: i) All marketed and non-marketed benefits (*ecosystem services*) derived from any ecosystem, including direct, indirect, option and *non-use value*s, or ii) The total *value* to all beneficiaries (consumer, producer, government, local, foreign) from any *ecosystem* service.

U *Use value*: *Economic value* derived from the human use of an ecosystem. It is the sum of direct use, indirect use and *option value*s.

User cost: The cost incurred over a period of time by the owner of a fixed asset as a consequence of using it to provide a flow of capital or consumption services; the implications of cur*rent* consumption decisions on future opportunity. *User cost* is the depreciation on the asset resulting from its use.

Utilitarian value: A measure of human *welfare* or satisfaction. Synonymous with *economic value*.

V *Valuation*: The process or practice of estimating human benefits of *ecosystem services* or costs of damages to *ecosystem services*, represented in monetary units.

Value: The contribution of an action or object to human wellbeing (social *welfare*).

Value-added: The difference between cost of inputs and the price of the produced good or service. *Value-added* can be computed for intermediate and final goods and services. *Value-added*, *profit*, and *producer surplus* are similar measures of the net benefit to producers. Although they differ slightly, the terms are used synonymously for this report to represent *economic value*.

W *Welfare*: An individual's satisfaction of their wants and needs. The human satisfaction or utility generated from a good or service.

Willingness-to-accept: The minimum amount of money an individual requires as compensation in order to forego a good or service.

Willingness-to-pay: The maximum amount of money an individual would pay in order to obtain a good, service, or avoid a change in condition.

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- Anne Rasmussen and Francis Reupena from Climate Change and GEF for information related to government projects
- Grace Laulala for assisting with information on sand and aggregate mining
- Wesley Hakai for disaster related information
- Papali'I Benjamin Sila and Mose Topeto from Bureau of Statistics for clarifying and sharing information on Samoa's economy and social statistics
- Teleiai Sapa Saifaleuplou from Siosiomanga Conservation Society for providing information on civil society operations
- Fuimaono Vaitolo Ofoia for providing information on SUNGO operations
- Peter Davis, Karen Baird and Juney Ward - Secretariat of the Pacific Regional Environment Programme (SPREP)
- Francella Strickland and Nella Tavita of the Ministry of Foreign Affairs and Trades (MFAT) Samoa
- Lilomaiava Filifilia Iosefa and Anne Trevor of the Regional Office, UNDP, Samoa
- Ms. Anastasia Amoa-Stowers, of the Maritime Division, Ministry of Works, Transport and Infrastructures (MWIT) for sharing maritime information
- Leiataua Eteuati Eteuati, President of Samoa Commercial Fishermen's' Association for providing reports on commercial fishing operation.
- Seuseu Dr. Joseph Tauati, of the Scientific Research Organisation of Samoa (SROS) for sharing scientific research information and reports
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- Nicholas Conner from the IUCN Commission on Environmental, Economic and Social Policy for reviewing the report.

13. Appendix:

stakeholder consultations, attendee lists

Contact	Institution
Ministry of Agriculture and Fisheries (MAF)	
Mr Magele Etuati Ropeti	ACEO – Fisheries Division,
Mr Autalavou Taua	Principle Fisheries Officer – (Advisory and Community Fisheries)
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Ms Francella Strickland	ACEO, International Division
Ministry of Natural Resources and Environment	
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Mr Seumalo Afele	ACEO – Division for Environment and Conservation
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Land Management	
Ms Galumalumana Filisita Heather	ACEO MNRE, Land Management
Ms Grace Laulala	Principal Officer, Land Division
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Ministry of Finance	
Ms Litara Tauialo	GEF coordinator
Mr Peresitene Kirifi	ACEO – Aid Coordination and Debt Management
FAO – Regional Office, UN Compound	
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Mr Fuimaono Vaitolo Ofoia	CEO – Samoa Umbrella for Non-Government Organisations (SUNGO)
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Contact	Institution
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Ms Anne Patricia Trevor	Program Officer Environment and Climate Change Multi-Country Office for Samoa, Niue & Tokelau
Samoa Tourism Authority	
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Mr Tumua Anthony McCarthy	Principal Agritourism Officer
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Ms Juney Ward	Threatened and Migratory Species Adviser
Orther organizations	
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Ms Anastacia Amoa-Stowers	ACEO, Maritime Division Ministry of Works, Transport, and Infrastructure (MWTI)
Ms Malama Siamomua- Mo-moemausu	Consultant, Think Environment Consult
Dr Teleai Sapa Saifaleupolu	CEO, Le Siosiomaga Conservation Society

Departments and Institutions visited and or contacted during bilateral consultations for the MESV study

Time	Institutions
5 March - 9:00 am	**Ministry of Agriculture and Fisheries** *Offshore fisheries section* Mr Matai'a Ueta Faasili (Principal Fisheries Officer) *Coastal fisheries section* Ms Sapeti Tiitii (Principal Fisheries Officer) *Advisory, Community Fisheries* Mr. Taua Autalavou Tauaefa (Principal Fisheries Officer) Mr Magele Eteuati Ropeti, *ACEO, Fisheries Division*
5 March - 2:00 pm	**Ministry of Foreign Affairs and Trade** Ms Nella Tavita Levy, *ACEO Trade Division* Ms Francella Strickland, *ACEO International Division*
6 March – 9:00 am	**Ministry of Natural Resources and Environment** Mr Seumalo Afele, *ACEO, Division of Environment and Conservation* Ms Maria R Satoa, *Principal Marine Biodiversity Conservation Officer* Ms Anne Rasmussen, *ACEO, Climate Change and GEF* Ms Francis Brown-Reupena, *Environment Sector Coordinator, Ocean Accounts* Ms Galumalumana Filisita, *ACEO, Land Management* Ms. Grace Laulala, *Principal Officer, Land Division*
9 March – 9:30 am	Mr. Lameko Asora, *ACEO, Disaster Management Office (MNRE)*
9 March – 1:00 pm	**Ministry of Finance** Ms. Litara Tauialo, *GEF coordinator* Economic – aid coordination unit
9 March – 3:30 pm	Mr. Fuimaono Vatolo Ofoia, *CEO, SUNGO* Phone: 7524322; ceo@sungo.ws (List of NGOs - environment, coastal, marine related)
10 March – 9:00 am	**Samoa Bureau of Statistics** Papalii Benjamin Sila, *ACEO, Social Statistics and Environment Division* Mose Topeto, *Principal Statistic Officer*
10 March – 11:00am	UNDP Lilomaiava Filifilia Iosefa, *SGP/UNDP Project Coordinator* Ms. Anne Trevor, *UN Climate Change Programme Officer*
10 March – 3:00 pm	**Samoa Tourism Authority** Tupai Kitiona Pogi Tumua Anthony McCarthy

10 March – 3:30 pm	**Chinese Embassy** Economic & Commercial Counsellor Vailima, 20802; 21638
11 March – 9:30 am	**Ausaid (Australian High Commission)** Beach Road Phone: 23411
11 March – 10:30 am	**NZaid (New Zealand High Commission)** Beach Road Phone: 21711
11 March – 1:00 pm	Karen Baird, *SPREP, Threatened Species and Marine Adviser*
11 March – 3:00 pm	Seuseu Dr Joseph Tauati, *CEO, Scientific Research Office of Samoa (SROS)*
12 March – 10:00 am	Dr Peter Davis, *SPREP, Coastal & Marine Ecosystems Adviser*
12 March – 1pm	**Ministry of Finance**
12 March – 2:00 pm	**Japanese Embassy** SNPF Plaza Level 3 Building B Phone 22572, Fax 22194
12 March – 3:30pm	MESV Consultant and PC meet with Leiataua Eteuati Eteuati, President of Samoa Commercial Fishermen's' Organisation
13 March – 10:00 am	Ms. Anastasia Amoa-Stowers, *ACEO Maritime Division,* *Ministry of Works, Transports and Infrastructures (MWIT)*
13 March – 10:00 am	Ms. Danita Strickland, *Conservation International* +68521593 (Ocean health Index)
13 March – 2:30 pm	**Ministry of Education Sports and Culture** Policy, Planning and Research Division
13 March – 3:30 pm	**USA Embassy** ACC Building, Matafele, 21436, 21631

SUMA Workshop List of Participants

Implementing Samoa's Ocean Strategy
Identifying Special, Unique Marine Areas for Samoa
4th March 2020
Sheraton Samoa Aggie Grey's Hotel & Bungalows, Main Beach Road - Apia, Samoa

Names	Organisation
Peter Davies	Secretariat to the Pacific Regional Environment Programmes (SPREP)
Seumalo Afele Fa'ilagi	Ministry of Natural Resources and Environment (MNRE)
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Chinnamma Reddy	IUCN – ORO
John Kaitu'u	IUCN – ORO
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Tevita Apulu	Fisheries Division, Ministry of Agriculture and Fisheries (MAF)
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Puna Luatimu	Fagalii Community-based Fisheries Committee
Unity Roebeck	Fisheries Division, Ministry of Agriculture and Fisheries (MAF)
Leilua Tavas Leota	Fagaloa Community-based Fisheries Committee
Peni Sua	Samoa Commercial Fishermen Association
Leiataua Eteuati Eteuati	Commercial Fishermen Association
Chinnamma Reddy	IUCN
Atonio P. Mulipola	IUCN/MNRE/SUNGO
Karen Baird	SPREP
Vina Ram Bidesi	Consultant – Marine Ecosystem Service Valuation Project
Unity Roebeck	Fisheries Division, Ministry of Agriculture and Fisheries (MAF)

14. APPENDIX INFORMATION

Appendix to Coastal Protection

Table 14.1: Number of affected housing units

Region	Totally damaged	Partially damaged	Minor damage	Total
Apia Urban Area	62	94	722	928
Rest of Upolu	187	243	652	1082
Northwest Upolu	3	9	34	46
Savai'i	1	7	24	32
TOTAL	253	353	1482	2088

Source: Extracted from (Government of Samoa, 2013 b: 56).

The replacement cost per building for residences in rural and urban areas were taken from (World Bank, 2013 b, p. 20). The median price for urban areas was applied to Apia urban area, while the rural residential price was used for other regions. The median price was used per building instead of the mean price because a small percentage of buildings are very expensive with multiple storeys, and/or a very large floor area.

Table 14.2: Tourism capacity in Samoa in 2012

Category	No.	Damaged *SAT$ (m)*	Average cost per hotel type *SAT$ (m) 2013 prices*
Deluxe	10	19.2	1.92
Superior Standard	11	**2.3**	0.209
Standard	29	0.5	0.45
Holiday Homes	3	1.1	2.98
Budget	36	2.9	0.73
Beach fales - overnight	20	0.5	0.55
Beach fales – day visit	13	0.2	0.18
Total		**26.7**	

Source: Extracted from (Government of Samoa, 2013 b)

The total *value* of destroyed assets in terms of replacement *value* was SAT$26.7 million.

Table 14.3: Number of coastal tourism accommodation in Samoa in 2020

Type of Accommodation	Apia urban area	Rest of Upolu	Northwest Upolu	Savai'i	Total
Deluxe	3	6	2	2	13
Standard superior	6	2	-	2	10
Standard	14	3	3	6	26
Budget	18	13	4	2	37
Holiday Hohme	2	0	-	-	2
Beach fale – overnight	-	12	-	10	22
Beach fale – day visit	-	16	-	-	16
Total:	43	52	9	22	126

Source: Extracted from Samoa Tourism Authority Database, 2020

Table 14.4: Replacement cost prices for Samoa in US Dollars

Residential Replacement Cost [1]	Urban	Rural	Non-residential replacement cost [1]	Urban	Rural
Average house price (2010 price)	81,295	7,340	Average Price (2010 price)	285,126	71,682
Average house price (2019 price)[2]	145,518	13,139	Average Price (2019 price)	510,375	128,311
Median house Price (2010 price)	30,042	3,149			
Median house Price (2019 price	53,775	5,637			

Note: (World Bank, 2013 b)
Average *inflation* rate 1.79

Table 14.5: Expected *value* of flood damages to houses without reefs (US$)

	Apia Urban Area	Rest of Upolu (ROU)	Northwest Upolu	Savai'i
P_t= probability of storm surge in year t	0.4	0.4	0.4	0.4
CPI= coastal protection index	0.54	0.51	0.46	0.51
A= assets at risk (houses)	1,021	1,190	51	35
C= Construction cost (house)	53,775	5,637	5,637	5,637
DF= damage factor (% of construction cost)	0.65	0.65	0.65	0.65
D_t= expected flood damage in year t (houses)	6,566,551	854,603	40,363	25,135

Table 14.6: Expected *value* of flood damages to tourist accommodation without reefs (US$)

	Apia Urban Area	Rest of Upolu (ROU)	Northwest Upolu	Savai'i
P_t= probability of storm surge in year t	0.4	0.4	0.4	0.4
CPI= coastal protection index	0.54	0.51	0.46	0.51
A= assets at risk (hotels, resorts, fales)	42	51	9	21
C= Average construction cost (tourist accommodation)	510,375	128,311	128,311	128,311
DF= damage factor (% of construction cost)	0.65	0.65	0.65	0.65
D_t= expected flood damage in year t (houses)	2,563,716	833,688	162,134	343,283