REPORT

Good Practice in Environmental Impact Assessment for Coastal Engineering in the Pacific

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Glossary

Area of influence: the area affected by a development project, which is beyond the project footprint. It may be upstream and/or downstream of the project site and include the wider catchment, watershed, coastal/ocean zone, airshed or buffer zones; an off-site resettlement zone; and areas that are culturally significant or used for livelihood activities. The area of influence is determined by a project's resource requirements and the nature and magnitude of its impacts, and it may vary across different development phases of a project. Can also referred to as a 'zone of influence'.

Baseline: a description of pre-development or current environmental conditions of a project's area of influence. In assessing the 'do-nothing' (no development) scenario, an impact assessment should consider how the pre-development baseline would evolve without the project.

Biomimicry: is a practice that learns from and mimics the strategies found in nature to solve human design challenges. It encompasses habitat creation (e.g., wetland creation) and translocation (e.g., coral gardens).

Climate change: long-term changes in climate conditions, i.e., changes in the mean and/or the variability of a property of climate, such as precipitation, temperature or wind force. These changes persist for an extended period, typically a decade or longer. Climate change can influence and alter the scale, scope, frequency and intensity of disaster risks.

Coastal development: any physical development that occurs in the coastal environment or coastal zone (see below). Entire islands may be in the coastal zone, especially if they are small low-lying or atolls.

Coastal zone: the area over which the sea has an influence; with its inland extent typically taken to be Mean High Water Spring tides. This may be extend from the transition to upland forest out to the reef edge.

Cumulative impacts: changes in the environment resulting from the combined, incremental effects of past, present and future human activities; environmental change (e.g., climate change); and physical events. Physical events can be of natural or human origin and may include extreme weather events and natural or human-induced disasters.

Disaster: severe, adverse disruption to the normal functioning of a community, society or ecosystem due to hazardous events interacting with vulnerable social and/or ecological conditions. Can cause widespread human, material, economic and/or environmental losses.

Ecosystem-based management: an integrated, holistic approach to achieving environmental, social and economic goals across "ridge-to-reef" or "whole-of-island" areas, typically combining land-use and development planning with environmental protection and production needs.

Environment: encompasses natural and biophysical, social (people, culture, health, heritage, amenity) and economic aspects, and the relationships between these different aspects.

Environmental hazard: an event or action that has the potential to cause significant impacts on a community, society or ecosystem. Environmental hazards can be natural (e.g., cyclone, flood, earthquake, tsunami, volcanic eruption, drought, landslide), human-induced (e.g., oil spill) or technological (e.g., infrastructure failure) in origin. They are not impacts (or disasters) in themselves but have the potential to cause them.

Environmental impact assessment (EIA): a process for identifying and managing a development or project's potential impacts on the environment, and the potential impacts of the environment on a development. Refer to SPREP (2016) *Strengthening environmental impact assessment (EIA) guidelines for Pacific Island countries and territories (PICT).*

Environmental impact assessment report (EIA report) or environmental impact statement (EIS): the document prepared by or on behalf of the development proponent as part of the EIA process, which details the project type, its timeframe and scale, likely impacts and impact significance, proposed impact mitigation measures (for negative impacts) and optimisation measures (for positive impacts), and monitoring requirements.

Environmental management plan (EMMP): a project specific plan that describes all mitigation measures and monitoring and reporting actions to be undertaken by the project proponent. An EMMP should include a schedule and assign responsibility to particular personnel (or roles) for undertaking mitigation measures and monitoring and reporting on a project's environmental performance to regulatory authorities.

Environment Officer: the member of the contractor's team responsible for monitoring and ensuring environmental performance. Generally answerable to the PICT Department of Environment.

Environmental, social and cultural assets: tangible and intangible assets that are valued and enjoyed by residents and visitors to the Pacific. Examples of 'environmental assets' include areas of particular ecological significance, national parks, community reserves, protected areas, forests, mangroves, seagrass beds, coral reefs, beaches, cliffs, blowholes, rivers, waterfalls, streams, wetlands, freshwater springs, waterholes, as well as plants and animals (especially species that are native, endemic or threatened). Examples of 'social assets' include land and other resources that customary owners have given their approval to share with local community groups and networks, tourists, and local businesses, as well as local knowledge, community facilities, utilities and transport. Examples of 'cultural assets' include cultural heritage sites and environments, physical structures, historical places, cultural knowledge and practices, museums and collections, art and live performances.

Geographic Information System (GIS): software used to spatially analyse environmental, social, economic and engineering datasets to help identify development risks, impacts and opportunities, and assess different development options. GIS can produce informative visual materials (e.g. maps) to support stakeholder communication throughout the entire EIA process.

Impact: a negative or positive change as a result of an action, activity or event. Refers to the impact of a project on the environment, as well as the impact of the environment on a project due to an environmental hazard or change. Examples of negative impacts include degradation of ecosystem services, loss of life or injury, property or infrastructure damage, and social unrest. Examples of positive impacts include environmental recovery and restoration, increased food security, property or infrastructure improvements, and increased local job opportunities.

Intertidal zone: is the area where the ocean meets the land between high (MHWS) and low (MLWS) tides. This zone is intermittently wet and dry. The **subtidal zone** is seawards of the intertidal zone and always wet.

Mitigation: measures or actions taken by a project proponent to address the impacts identified through the EIA process. Mitigation measures should follow the impact mitigation hierarchy and be detailed in an EMMP. The mitigation hierarchy, in order of preference, is avoid negative impacts, minimise negative impacts that cannot be avoided, rehabilitate or remedy negative impacts that cannot be minimised, and offset (or compensate for) negative impacts that cannot be remedied.

Noumea Convention: The Convention for the Protection of Natural Resources and Environment of the South Pacific Region and its Protocols obliges Parties to endeavour to take all appropriate measures to prevent, reduce and control pollution from any source and to ensure sound environmental management and development of natural resources, using the best practicable means at their disposal and in accordance with their capabilities. Ten Pacific countries are Party to the Noumea Convention.

Project footprint: the land and/or ocean area occupied by project buildings, facilities, infrastructure or activities.

Project proponent: an individual, company or government ministry/department/agency planning to undertake a development or project.

Residual effects: those effects (or impacts) that are predicted to remain once mitigation has been implemented.

Resilience: the ability of a community or system (human and/or natural) to sustain itself, to respond to and recover from extreme events and disturbances, or to use extreme events and disturbances as an opportunity for renewal and positive transformation.

Stakeholder: any person, organisation, institution or business who has interests in, or is affected by, a development or project issue or activity, including local community members and customary land/resource owners.

Strategic environmental assessment: a higher-level assessment process that can be used to: (1) prepare a strategic development or resource use plan for a defined land and/or ocean area, (2) examine the potential environmental impacts associated with the implementation of government policies, plans and programmes, (3) produce general environmental management policies or design guidelines for different classes/types of development. See SPREP (2020) *Strategic Environmental Assessment (SEA) Guidelines for PICT.*

Vulnerability: the sensitivity of a development, human community or ecosystem to damage and loss resulting from a hazardous event or disturbance.

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Abbreviations

ADB	Asian Development Bank
CBD	Convention on Biological Diversity
CLO	community liaison officer
dB	decibels
EIA	environmental impact assessment
EIS	environmental impact statement
EMMP	environmental management plan
ERP	emergency response plan
FRDP	Framework for Resilient Development in the Pacific 2017–2030
GIS	geographic information system
GRM	grievance redress mechanism
HIV/AIDS	human immunodeficiency virus / acquired immunodeficiency syndrome
IUCN	International Union for Nature Conservation
LiDAR	light detection and ranging remote sensing system
MEA	multilateral environmental agreement
MCA	multi criteria analysis
MHWS	mean high water spring tides
MLWS	mean low water spring tides
MSL	mean sea level
NGOs	non-governmental organisations
PICT	Pacific Island countries and territories
PPE	protective personal equipment
SDG	United Nations Sustainable Development Goals
SEA	strategic environmental assessment
SIA	social impact assessment
SIDS	small island developing states
SPREP	Secretariat of the Pacific Regional Environment Programme
SSC	suspended sediment concentration
STI	sexually transmitted infection
ToR	terms of reference
UNFCCC	United Nations Framework Convention on Climate Change
UXO	unexploded ordnance (typically associated with World War II)

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1 Introduction

1.1 Guidance on EIA

Environmental impact assessment (EIA) is a process that is used to assess and manage individual development projects, by identifying and mitigating the developments impact on the environment and the environments impact on the development (or project). The EIA process aims to maximise positive benefits and minimising negative impacts for local communities and their environment. When implemented correctly, EIA can help to support the achievement of green growth targets, climate change resilience, and the United Nations Sustainable Development Goals (SDGs)[1].

Across the Pacific, the Secretariat of the Pacific Regional Environment Programme (SPREP) has been promoting the use of EIA and delivering EIA capacity-building for more than twenty-five years. In 2016 SPREP member countries endorsed new regional EIA guidelines *Strengthening environmental impact assessment: Guidelines for Pacific island countries and territories (PICT) (SPREP, 2016).* The Regional EIA Guidelines provide a detailed overview of EIA and offer practical tips and tools to support PICT government officers with managing the EIA process. They do not provide details on how to assess and mitigate impacts from specific developments, including the many projects in the Pacific that entail coastal engineering.

Coastal environments are biologically productive and ecologically diverse; they supply valuable resources to support Pacific island lifestyles, livelihoods and cultural practices; and they provide critical natural defences against storms, cyclones, tsunami, flooding and erosion, the frequency of which is expected to increase with climate change. Coastal engineering projects can make a positive contribution to Pacific island countries and territories as long as they are designed to ensure that important coastal areas are not degraded and EIA can play an important role in ensuring this.

Given this, SPREP determined that guidance on good practice in EIA – scoping, data collection, impact assessment, mitigation, and monitoring and management – for coastal development, adaptation and engineering projects would be valuable and this report was born in line with Objective 4.1 of SPREP's *Strategic Plan 2017–2026* [2]. The guidance provided is designed to support PICT governments in meeting their obligations to undertake, require and review EIAs for coastal development, in line with the multilateral environmental agreements (MEAs) to which they are party (Section 2.2).

1.2 Aims and Targets

The aims of the Coastal Impact Assessment Good Practice Guide are to:

1. Increase awareness and understanding of the EIA process across PICT.
2. Promote good practice in EIA for coastal engineering projects.
3. Encourage government agencies and developers to comply with national EIA regulatory frameworks and, in the absence of these, to follow regional EIA guidance.
4. Support sustainable and resilient coastal development that protects environmental, social and cultural assets.

[1] THE 17 GOALS | Sustainable Development (un.org)
[2] *To "Strengthen national sustainable development planning and implementation systems including through use of Environmental Impact Assessments, Strategic Environmental Assessments, and spatial planning".*

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The EIA guidelines are intended for:

- Government officers who are responsible for managing or providing input into the EIA process.
- SPREP members.
- Marine businesses and operators, both small and large.
- National marine and coastal development associations.
- Customary and private land and resource owners.
- Members of civil society organisations and local community groups who have an interest in coastal development and EIA.

1.3 This Guidance Note

SPREP's *Strategic Plan 2017-2026* recognises that the people and environment of the Pacific benefit from commitment to and best practice in environmental governance. Good environmental governance is supported by regulation and a structured process for the environmental assessment of development, as well as the mitigation of adverse effects, monitoring and appropriate environmental management. Each one is dependent on the other and benefits from thorough but straight forward guidance.

The Regional EIA Guidelines (SPREP, 2016), as well as the *EIA guidelines for coastal tourism development in PICT* (SPREP, 2018) and *Strategic Environmental Assessment (SEA) Guidelines for PICT* (SPREP, 2020), have been effectively used in the Pacific and have facilitated improvements in EIA processes, its management and awareness. They have built capacity, but the broad descriptions provided are limited regarding the specific assessment of coastal development and adaptation projects and in the design of associated mitigation and management measures. With the challenges presented by climate change (including drought, floods, coastal erosion / inundation and salinisation) and the vulnerability of PICT, such projects will only become more important and need to be assessed appropriately.

SPREP 2016 provides guidance on the general EIA process for PICT by:

- Emphasising the importance of assessing the potential impacts of development on the environment and the potential impacts of the environment on development, especially impacts related to climate change and disasters.
- Providing a clear overview of the EIA process, supported by an Environmental management Plan (EMMP) toolkit that includes templates and checklists for EMMP scoping, mitigation measures, reporting, monitoring, and review.
- Providing information on the type of baseline studies that are required to support certain investigations and the forms of assessment that are appropriate (or can be applied, e.g., where there is a lack of resources) in different circumstances.
- Introducing the concept of SEA, an approach that provides context for EIA by identifying what forms of development are environmentally sound and appropriate; pinpointing locations where developments are/are not permissible; stipulating desired types and characteristics of developments; and identifying broad environmental management measures that are advocated.
- Setting out considerations and recommendations for effective EIA in the Pacific.
- Providing guidance to Pacific Island countries should they wish to develop their own national EIA guidelines.
- Linking the EIA process to MEAs.

The general approach to impact assessment advocated is consistent across the SPREP documents and the SPREP core priority areas – of climate change resilience, island and ocean ecosystems, effective waste management and pollution control and environmental governance – are evident. This Good Practice Guide does not make alterations to this established EIA process (shown in **Figure 1**), rather it builds upon it, with a specific coastal engineering, adaptation and management focus. It aims to provide specific examples, approaches and mitigation measures relevant to the coastal environment.

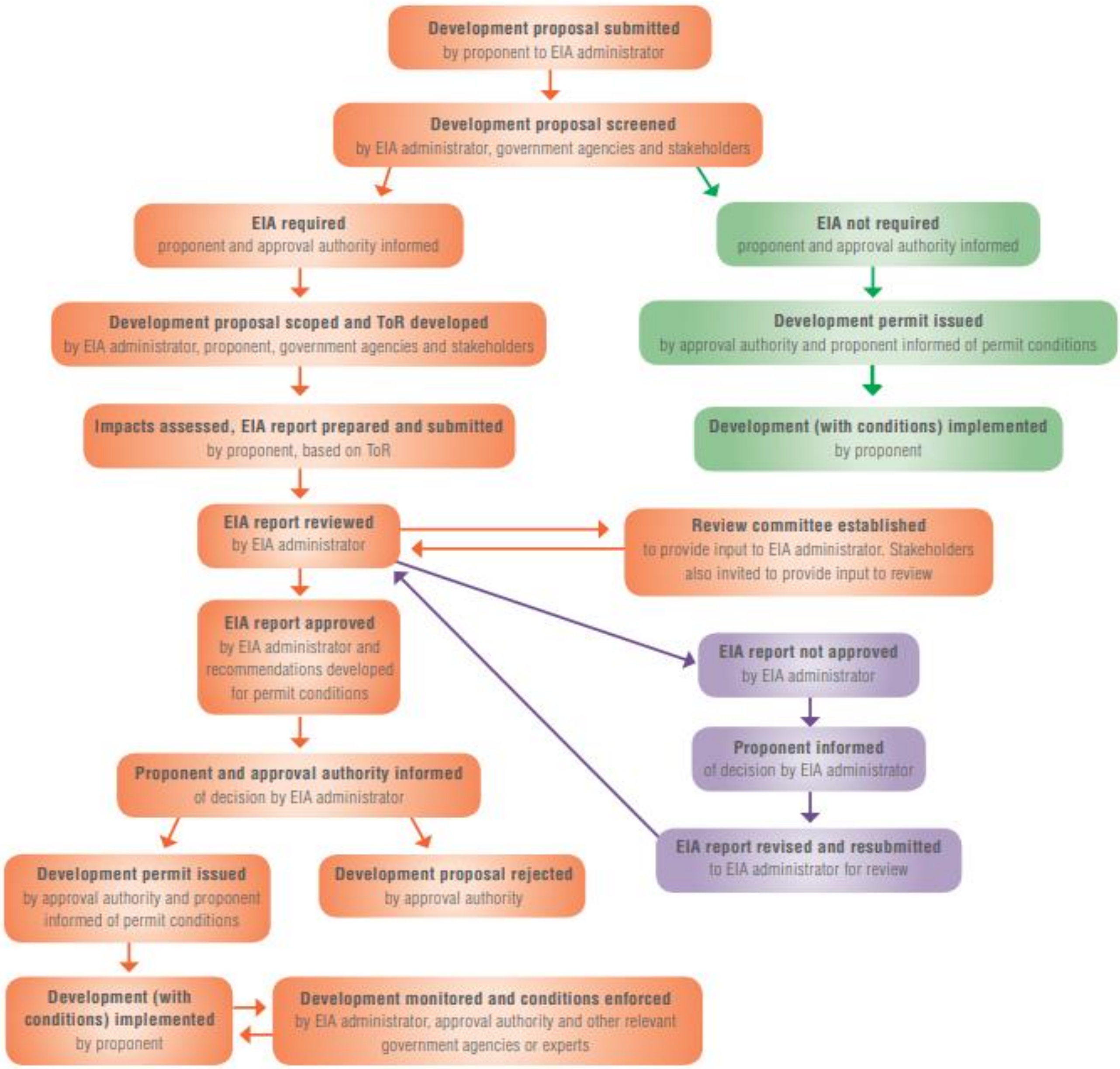

Figure 1: EIA process

2 The Pacific

2.1 Pacific Context

The Pacific Ocean covers one third of the Earth's surface and is one of the world's largest active carbon sinks. It has an immense biodiversity, with as little as 20% of its flora and fauna having been properly researched. The Pacific Islands are characterised by extremes in physical geography and remoteness. For example, Tuvalu consists of six coralline atolls (Nanumea, Nui, Nukufetau, Funafuti, Nukulaelae, Vaitupu) and three table reef islands (Nanumaga, Niutao, Niulakita), with a total land mass of some 26km^2 spread across an economic zone of 757,000km^2, which is more than 1,100km from its closest neighbour, Fiji. The environmental profile of the region is one of high degrees of endemism and levels of biodiversity, but relatively small numbers of species. There is a high degree of economic and cultural dependence on the natural environment and a clear vulnerability to climate change and a wide range of natural disasters (Mimura, 1999). The social profile of the region, in the context of EIA, is one of high levels of education but a lack of direct experience and resource sharing (rather than specialisation).

The Pacific region is blessed with coral reefs and their ecosystems. More than 80% of Pacific islanders live in or near coastal areas and draw from the coral reefs for their livelihood. The reefs support approximately 25% of all marine life, including over 4,000 species of fish, providing valuable spawning, nursery, refuge and feeding areas for large varieties of organisms. Coral reefs also play vital roles as natural breakwaters, minimising wave impacts during storms and cyclones (Marto, Papageorgiou, & Klyuev, 2017).

At the regional level, the inter-relatedness of the economic and ecological characteristics of the islands is manifest in several areas. Natural resources, such as water, vegetation, soil, near-shore systems, and wildlife, ultimately dictate the capacity of islands to accept and sustain development. For islands, resource productivity is intricately linked to the function of neighbouring ecosystems, such that damage to one ecosystem invariably impacts on other ecosystems, and to a much greater degree than is the case for continental societies.

Pacific nations rank among the most vulnerable in the world to natural disasters. Between 1950 and 2004, extreme natural disasters, such as cyclones, droughts, and tsunamis, accounted for 65 percent of the total economic impact from disasters on the region’s economies. Further, ten of the fifteen most extreme events reported over the past half century have occurred in the last fifteen years (Rahman, 2016).

2.2 Pacific Approach

From the late 1980s onwards, EIA awareness and application began to be widely promoted in regional and international MEAs, to which many SPREP members are party, such as the:

- Convention for the Protection of the Natural Resources and the Environment of the South Pacific Region (Noumea Convention);
- Rio Declaration on Environment and Development (Rio Declaration);
- Convention on Biological Diversity (CBD); and,
- United Nations Framework Convention on Climate Change (UNFCCC).

In the years that have followed, EIA has been adopted and legislated by most countries around the world and used to assess both public and private development projects. In the Pacific, project-scale EIA was initially introduced in association with projects funded by the Asian Development Bank and The World Bank. During the 1990s and 2000s, Pacific countries started to incorporate EIA into their national environmental policies and legislation. SPREP helped to facilitate the uptake of EIA by providing educational publications and training, hands-on assistance. All Pacific island countries, with the exception of Nauru, now have legislation in place that provides substantive provisions for EIA application. However, despite the widespread adoption of EIA, a number of countries are still learning how to use the tool to maximum effect; especially within the context of staffing, financial and technical resource constraints, and in terms

Nassau, The Cook Islands

EIA requirements can change in PICT based on traditional governance structures and should always be checked at both a National and island/island group level.

For example, The Cook Islands Environment Act 2003 does not apply on the remote island of Nassau (or on two other Cook Islands) because the Island has a traditional leader in place, with a higher status than the Government, and is governed by traditional rule. Hence the EIA undertaken for their Harbour improvement took the form of an ‘Environment Report’ (not an EIA under the 2003 Act).

of the need to comprehensively assess and address the social impacts of development and the potential impacts the environment may have on development.

Most SPREP member countries and territories have EIA legislation, thus, EIA is a compulsory part of their development planning and assessment processes, but experience in its application is limited. The EIA process is commonly applied or triggered as a legal requirement for gaining development approval, or at the request of funding agencies and financial lending institutions who seek to encourage sustainable and accountable development.

3 Coastal Engineering Project Types

For ease, ‘coastal engineering’ is used herein as a catch all for coastal engineering, coastal management, and coastal adaptation projects.

Coastal engineering involves the planning, design, construction and maintenance of works aimed at protecting or adapting shorelines, reclaiming land from the sea, countering subsidence, facilitating navigation and providing marine facilities, and ecosystem enhancement and restoration. Broad categories of coastal engineering activities and projects typical of the Pacific region are described below.

3.1 Dredging and Excavation

Dredging typically involves removing sediment (sand, silt and mud) from below water to create the required depth for the safe navigation of vessels or to win material (sand) as a resource. Excavation typically involves removing rock or coral platforms to achieve the required depth for safe navigation or to enable the construction of a jetty or harbour. Dredging and excavation are a common part of coastal development projects in the Pacific due to the reliance on marine transport and the requirement to provide access for vessels to land though coralline platforms and table reefs.

The impact of mining beach sand and other aggregates for construction purposes on Pacific islands has significantly affected coastal processes and their coastal environments. Consequently, in most Pacific countries and territories, the removal of beach gravels and sands is now restricted. In Tuvalu, no person shall remove from the foreshore any sand, gravel, reef mud, coral or other like substances without having first obtained a license for that purpose from the Kaupule in whose area of authority such foreshore lies, and licenses will only be provided for personnel use (e.g., house building).

Nui Small Boat Harbour, Tuvalu

Dredging will include the removal of sand and rock from the bottom of the channel and the removal of solid coralline rock from the side walls, to create a turning basin within the reef platform. The proposed channel has been aligned to maximize its overlay with the existing channel to minimize the dredging requirements of the project and reduce its environmental impact.

The length of the existing channel will not change but the last 300m from the mouth will be enlarged to be a minimum of 20m and up to 40m wide in the turning basin and at its mouth to allow for safer access for small passenger vessels/work boats.

The channel will be dredged to a maximum depth of -3.30m below mean sea level (MSL) at its mouth, with two steps up to a level of -2.5m below MSL in the turning basin. These depths have been determined based on the tidal variation within the channel to ensure there is sufficient under keel clearance for the workboats at mean low water spring tides (MLWS).

The dredging will be carried out by 40- or 50-ton excavators using a hydraulic rock breaker and bucket attachments for the removal of the reef material, rather than the use of a grinder/suction head due the marginal economics of mobilizing such equipment for a remote island. Dredging from the reef platform would be limited to low tidal conditions, which would limit the plume, whereas dredging from a floating barge could occur for longer periods.

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3.2 Reclamation

Reclamation is raising the seabed or intertidal zone below the high-water mark above the high-water mark by depositing solid material that creates land on top of previously marine or coastal environment. The placement of such material typically needs to be contained by pilled walls, rock armour or rock baskets/bags. Many Pacific islands are constrained by lack of available land, meaning that reclamation may be viewed as an option to alleviate this. Reclamation (and land raising) may also be undertaken as an adaptation strategy due to sea level rise.

3.3 Port or Harbour

A port or harbour is an essential node in a supply chain. Most Pacific countries or territories have one major port that serves as its international hub for imports and exports and is of critical importance, representing a vital link for Pacific islands to other regions. Many other islands have harbours via which goods and services are transhipped. This includes the movement of people for essential health care, education, and social and cultural events. Some islands have neither. Port and harbours typically include fully enclosed (walled), reclaimed areas and piled structures.

Maritime Transport Master Plan, Tonga

Due to Tonga's relative isolation, spatial dispersion over a large area of the South Pacific and dependence on imports, international, regional, internal transport links are crucial. But in 2022 28% of its islands either have no wharfs or wharfs with significant damage that cannot be functionally used; 22% of its islands have wharfs that are significantly damaged but still functional (although not safe); and 22% if its islands have wharfs that have moderate damage, which impacts their function.

3.4 Jetty or Boat Ramp

By contrast to a port or harbour that may allow an interisland vessel to moor or, if small, work boats to moor (which transfer people and goods from the vessel to the harbour), many islands have simple piled jetties that can only accommodate small boats for the transfer or people and goods to and from work boats in the open ocean. Some islands simply have boat ramps, which may be concrete structures or flexi mats pinned to the seabed.

3.5 Breakwater

A breakwater is a coastal structure (usually a rock and rubble mound structure) projecting into the sea that can shelter vessels from waves and currents, prevent siltation of a navigation channel or protect a shore area. Breakwaters are mostly associated with marine facilities such as harbours or jetties.

3.6 Seawalls, Groynes and Other erosion protection measures

Hard structures are frequently constructed to prevent erosion of coastal landscapes and infrastructure and mitigate the risks to populations and economic activities. Coastal structures are usually built using materials (at least for certain coasts and beaches) that do not form naturally, such as concrete, large armour stone, steel (steel baskets and rock), or timber, are relatively permanent (typical with a 50-yr design life) and are spatially fixed within an otherwise dynamic coastal zone (see **Figure 2**); the consequence of which will often be the loss of the beach overtime.

Seawalls are onshore structures with the principal function of preventing erosion or alleviating overtopping and flooding of the land and the structures behind due to storm surges and waves. Seawalls are built parallel to the shoreline as a reinforcement of a part of the coastal profile. Quite often, seawalls are used to protect promenades, roads, and houses seaward of the crest edge of the natural beach profile. Seawalls range from vertical face structures (such as gravity concrete walls, tied walls using steel or concrete piling, and stone-filled cribwork) to sloping structures with typical surfaces being reinforced concrete slabs, concrete armour units, or stone rubble.

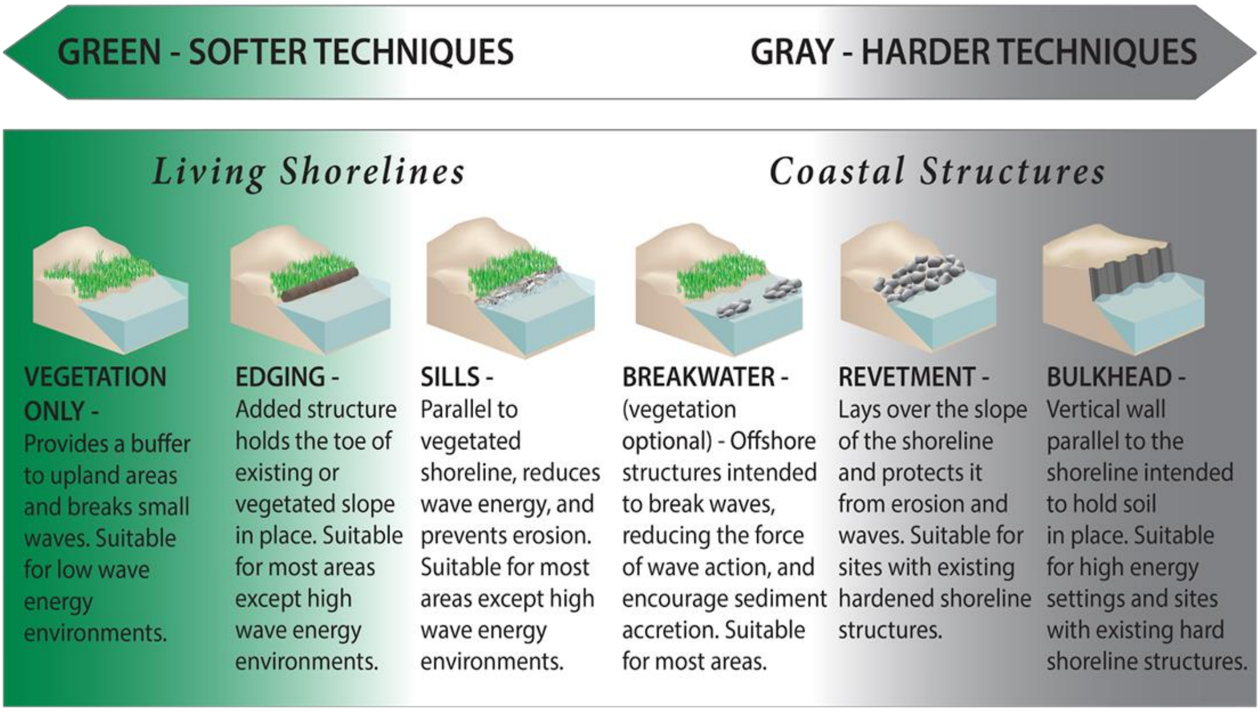

Figure 2: Green ('soft') and Gray ('hard') coast protection options (Source: (MfE, 2017) after living-shoreline.pdf (noaa.gov))

Groins are built perpendicular to the shore to stabilize a stretch of natural or artificially nourished beach against erosion that is due primarily to a net longshore loss of beach material. Groins function only when longshore transport occurs. Groins are narrow structures, usually straight and perpendicular to the pre-project shoreline. The effect of a single groin is the accretion of beach material on the updrift side and erosion on the downdrift side; both effects extend some distance from the structure.

Detached breakwaters are small, relatively short, non-shore-connected nearshore breakwaters with the principal function of reducing beach erosion. They are built parallel to the shore just seaward of the shoreline in shallow water depths, using solid concrete structures, piles of stone/concrete blocks, or rubble mound. Multiple detached breakwaters spaced along the shoreline can provide protection to substantial shoreline frontages.

Soft engineering includes engineering approaches to set back and stabilise dunes or planting (in a geotextile matrix or similar) and focusses on retaining the natural defences (through dune management, maintenance of sediment supply, maintaining healthy foreshore vegetation and wetlands, managing access and so on). It may include a buried revetment or seawall.

3.7 Beach Nourishment

Beach nourishment, or beach filling, is the practice of adding often large quantities of sand or sediment to beaches to combat erosion and increase beach width. Often referred to as a "soft armouring" technique, it is sometimes viewed as a superior alternative to hard armouring. With sea level rise and storms threatening to erode sandy beaches, it is likely that nourishment will become more prevalent. However, this approach will be limited in the Pacific by the availability (or lack of availability) of sand.

3.8 Biomimicry

In the context of coastal engineering projects in PICT, biomimicry can take the form of constructed wetlands, seagrass restoration, coral gardens, artificial reefs and planted mangrove forests.

Constructed wetlands are frequently designed to restore natural wetland habitats and ecosystems but can serve other purposes, often related to water or sewage filtration and treatment (as alternatives to more industrial processes). Natural wetlands and seagrass beds support significant biodiversity and particularly fish.

Coral gardening is a method of growing translocated coral polyps to help restore reefs. Sometimes called coral farming, this gardening method involves taking small coral fragments and growing them through asexual reproduction until they are mature. Ocean-based nurseries take coral fragments and grow them underwater. They attach the pieces to steel structures and monitor them, with the view to transplanting coral into degraded natural reefs.

Seagrass restoration, Kiribati

The Seagrass Restoration Guidelines for Kiribati [REF] discuss the multitude of methods available for undertaking restoration works. However, whether the proposal involves restoring seagrass beds, mangrove forests or wetlands, the considerations are similar. In brief, the proponent should consider:

- Site selection and habitat suitability - environmental conditions suited to the growth of the selected species.
- If there are suitable donor sites to populate the restoration area.
- Community participation - utilising local knowledge of the species and what is needed for it to thrive.
- Scale - larger areas are more likely to succeed than small areas.
- Cost - is it feasible to attempt the restoration?

An artificial reef is a human-made underwater structure that closely approaches or extends above the surface of the water. These reefs provide excellent habitats for marine life and are often built specifically for this purpose. In addition, reefs can protect nearby beaches from erosion.

If such measures are proposed as part of a mitigation strategy for a coastal engineering project, they must be supported through a long-term management programme and expert knowledge.

4 Supporting Studies

To assess the environmental effects of coastal engineering projects, similar studies are typically required to identify sensitive receptors and quantify potential impacts. These studies are discussed below.

A guide such as this cannot provide specific details of the level of investigation or detail required by a specific project, but it is important to be proportionate in determining survey requirements (i.e., where an effect is expected to be limited, the surveys commissioned can be higher level, whereas if an effect is expected to the significant detailed modelling (e.g., dredged plume modelling) may be required). Section 6.2 on Scoping provides further details. In some cases, a desktop study of available evidence can usefully be undertaken as a first step to determine the requirement, or not, for further investigation. **Table 1** provides an example of the environmental and social topics on which data was sought and the data sources for a coastal protection project in Ebeye, the Republic of the Marshall Islands (RMI).

Where feasible and/or appropriate, the use of standardised data collection methods and presentation formats should be encouraged, so that the same level of rigour applies across all developments.

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Developers should also be encouraged to present EIA data in a spatial format (using a GIS), to assist with understanding the physical location and extent of a development, and the scope and scale of impacts.

Table 1: EIA parameters and data sources for the Ebeye seawall, RMI

EIA parameter (topic)	Source of information
Physical Environment	
Geological Resources – soils, sands, reef flat, freshwater lens	Field studies (geotechnical survey); published data on 'borrow pits' (aggregate extraction sites)
Coastal Processes – waves, water levels, tides and erosion/sediment transport	Desktop studies; site observations; numerical modelling
Bathymetry and Topography	Field survey; LiDAR data
Wind and Temperature	Sourced from closest weather station
Natural Hazards – cyclones, tsunamis, volcanic activity and earthquakes	Desktop studies
Climate Change – sea level rise, rainfall, cyclonic intensity	Desktop studies; Pacific Climate Change Science Program of Australia - RMI
Noise	Baseline noise sampling during site investigations
Air Quality (dust)	Baseline dust sampling during site investigations
Biological Environment	
Terrestrial Ecology – flora, fauna and land use	Aerial imagery; CBD Reports (RMIEPA); ecological survey
Marine Ecology – coral reef health, fish/reptile/mammal assemblage, intertidal reef flat, marine ecosystem services	LiDAR imagery; ecological survey; coral reef mapping; State of Environment Report (SPREP)
Protected Areas – nationally protected, community managed and area uses	Pacific Islands Protected Area portal – SPREP; local government databases
Vulnerable and Endangered Species – endemic, rare and valuable species	IUCN Red List; CBD Reports; State of Environment Report (SPREP)
Invasive and Alien Species	National Biodiversity Strategy and Action Plan; National Invasive Species Action Plan; stakeholder engagement
Social Environment	
Landownership and Land Use	Stakeholder consultation; land records, lease records, land agency; satellite imagery
Demographics and Education	Census data; key informant interviews
Health and medical services and facilities	Desktop studies; key informant interviews; focus groups
Gender	Gender and Development Office consultation; focus group
Economy and Employment	Census data; informant interviews/focus groups; ADB reports
Cultural Resources	Desktop studies; consultation with traditional leaders
Vulnerable Persons – youth, elderly, disable persons	Desktop study; focus groups discussions
Infrastructure and Utilities	Development Project Reports; Development Plans; key informant interviews

4.1 Physical Resources

As for most EIAs, an EIA for a PICT coastal engineering project will begin with a description of the physical resources of the study area, including its geology, topography, hydrography, reefs, and soils. In the Pacific, it is also relevant to consider seismicity and volcanic activity. Of equal importance will be metocean and hydrodynamic conditions (coastal processes), and climate (including tropical cyclones) /

climate change – sea level rise but also increased storminess, increased intensity and frequency of rainfall and heat, and incidence of drought.

4.1.1 Hydrographic survey

A hydrographic survey maps the terrain of the sea floor (bathymetry) by determining the depth of an overlying water body. Hydrographic surveys are used for a range of applications in coastal engineering projects, including estimating sediment volumes during dredging, charting and ship navigation, and understanding nearshore/offshore coastal processes.

Hydrographic surveys may include the following:

- A survey plan to define the extent of the data to be collected.
- Physical field survey by an appropriately qualified surveyor.
- Data analysis and reporting.
- Data outputs that may include 2D and/or 3D mapping as well as data files for GIS input.

4.1.2 Geotechnical Investigation

The purpose of a geotechnical investigation is to understand the ground conditions below a development site. This will generally aim to understand the properties and distribution of geological units within the area for use in engineering design, construction or infrastructure planning.

A geotechnical investigation may include the following:

- Desk study: a review of available information and data prior to an on-site investigation.
- On-site investigations: including drilling, test pitting, in-situ testing etc.
- Laboratory testing: testing samples recovered from on-site investigations.
- Factual reporting: geotechnical logs, laboratory results and investigation methodologies.
- Interpretive reporting: reporting containing interpretation of the investigation results (e.g., design parameters, geotechnical construction advice, and geological cross sections).

The requirements of a geotechnical investigation will differ depending on the design requirements of a project, site conditions, available information, and site constraints. Generally, on-site geotechnical

Hydrographic Survey Methods

A variety of methods can be employed to determine horizontal location and vertical depth, however, global positioning systems (GPS), using differential or real time kinematic (RTK) corrections via an electronic single beam or multibeam echosounder, are the most common method for collecting hydrographic data. A weighted line and a survey tape can also be used.

Multibeam echosounders transmit sound signals and analyse the return signal that has bounced off the seafloor or other objects. Multibeam sonars emit sound waves from directly beneath a ship's hull to produce fan-shaped coverage of the seafloor. These systems measure and record the time for the signal to travel from the transmitter to the seafloor and back to the receiver. Multibeam surveys are the most expensive survey method but provide the clearest picture. It is the quickest collection method for large areas; however, more processing time is required than for other methods.

With **single beam echosounders** the sound is transmitted straight down in a focused beam, typically a 3-20° cone. This yields a single depth measurement from somewhere inside the 'beam'. Taken in a continuous string, a single beam echosounder produces a seafloor profile. Single beam echosounder do not record the average depth within the area of the beam on the seafloor. Rather the first sound return for each "ping" provides the depth. Therefore, the shallowest depth within the cone is recorded. In areas with a rough seafloor and/or large relief, this means that the "least depth" within the cone of transmitted sound is recorded, which can reduce accuracy. Single beam surveys are the most cost-effective way to obtain a survey of an area. These surveys can be collected and processed quickly when the equipment is available.

Leadline surveys have a long history in the maritime sector. This kind of manual survey has been replaced by echosounding for the most part, due to the improvements in data collection speed, accuracy and point density. Leadline surveys will generally require a boat, a surveyor's tape to measure range along a station, a weighted line marked to measure depth and an accurate tide gauge. Leadline surveys are a good alternative in situations when the equipment and resources do not allow for an echosound survey or the area to be surveyed is small.

investigations are not required to inform an EIA (desk study information is typically sufficient) but further detail can be informative.

4.1.3 Metocean assessment (meteorology, tides and waves)

Metocean refers to the study of meteorology and physical oceanography. In a coastal engineering context, these studies are primarily used to measure and assess wind, wave, tides, storm tides and climatic conditions that may influence a particular area and/or project.

A metocean study can be incorporated at various stages of coastal engineering projects but is typically undertaken in the early stages of a project to assist with defining design criteria, ranging in complexity from simply understanding the broad metocean conditions to providing detailed assessment of specific conditions (e.g., strength of cyclones, tidal influence, storm surge impact etc.).

Metocean assessments should aim to include the following:

1. Project definition (i.e., scope, objectives).
2. Collection and analysis of field data or data from established suitable global models (e.g., WaveWatch III).
3. Development of a ‘conceptual’ site model (assessing all influencing parameters).
4. Model selection, development, and calibration/uncertainty analysis.
5. Assessment of model predictions and outcomes to inform project design.

Metocean information on wind, waves, tides is required to inform EIA of coastal engineering projects, but existing information is often available and sufficient. Typically of more importance is hydrodynamic modelling, which requires metocean inputs, to predict the influence of any new structure in the coastal zone on coastal processes and, from this, on sedimentary process, water quality, ecology etc.

4.1.4 Coastal process modelling – hydrodynamic and morphodynamic

Hydrodynamic modelling is the study of fluids in motion. Many forces can be responsible for fluid motion, either acting alone or in combination with each other. In a coastal engineering context, these forces are typically generated by tides, winds and waves, together with topographic gradients and bodies of water meeting, such as oceans, rivers, wastewater outlets etc. Coastal morphodynamic (or geomorphodynamic) modelling refers to the study of the interaction and adjustment of the seafloor or coastal topography and hydrodynamic processes (or forces), involving the motion of sediment. Seabed features and structures will be impacted directly by hydrodynamic motion generated by these forces, which in turn will affect the fluids behaviour and hydrodynamic and morphodynamic processes (sediment transport).

A change in a forcing factor (such as the direction and strength of a tidal current due to the construction of a breakwater) does not mean that an impact will occur, but if that change affects water quality or sedimentary processes, then an impact may arise (typically on local ecology).

Coastal process modelling facilitates the understanding and quantification of these complex interactions and enables the development of effective coastal infrastructure. It is fundamental to coastal engineering EIA and typically includes the five steps set out above for metocean assessment. But, again, the effort invested in such should be proportionate to the effects predicted. For a major Port development or vertical seawall, a detailed hydrodynamic model and sediment transport assessment should be undertaken. For a jetty or boat ramp, or soft engineering solution, a conceptual coastal process model may be sufficient (see **Figure 3**).

4.1.5 Water quality monitoring and modelling

The purpose of water quality monitoring is to provide data on the health of water bodies and facilitate the effective management of catchments, water resources and the environment. Fundamentally, monitoring consists of a systematic and planned series of measurements or observations that are appropriately analysed and reported, to generate information and knowledge about a water body.

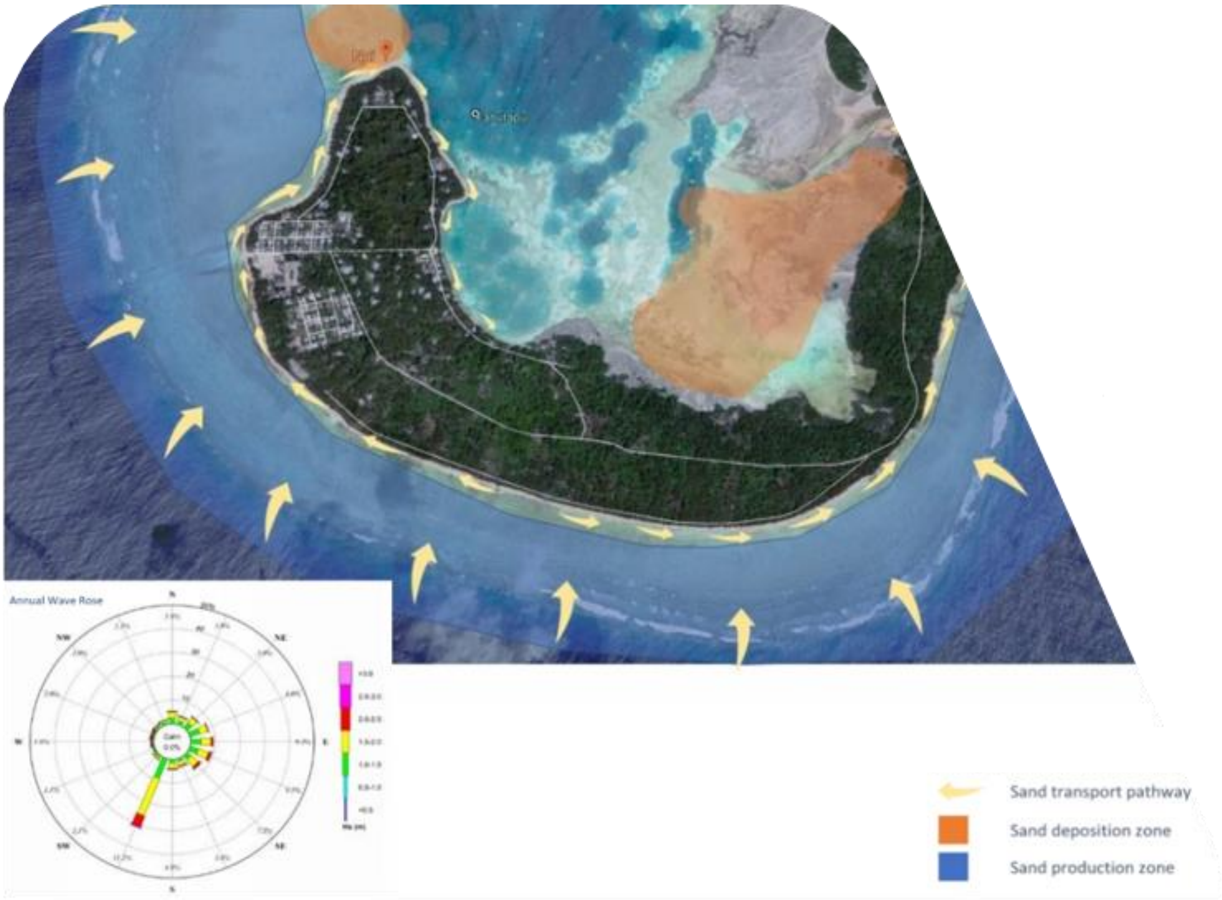

Figure 3: Conceptual coastal process model of Nui's southern coast, Tuvalu

As a general approach, a water quality monitoring study may include the following:

- Setting objectives, including defining water quality objectives for construction and operational phases of a project (e.g., suspended sediment levels in a defined area are not to exceed 10% of the range of the levels typically encountered in the water body for a defined time).
- Establishing the parameters and locations to be monitored (i.e., vis-à-vis sensitive receptors).
- Field sampling (of the baseline, during and post works conditions).
- Laboratory and data analysis.
- Reporting and modelling (if relevant).

Modelling water quality can be a useful tool in predicting and presenting the position and momentum of possible pollutants in a water body and can inform EIA where this is a significant risk.

4.2 Biological Resources

Ecological survey and assessment will facilitate the identification, prediction and evaluation of potential ecological impacts resulting from a project. The assessment should seek to protect and conserve the ecological value within and surrounding the project site. Generally, its content will be defined based on the environment potentially impacted and the type and scale of the project. The following will be included:

- Desk based assessment of available data.
- Baseline ecological survey – the scope of which will vary dependent on the identification of sensitive and/or important habitats and species (about which more may need to be known).
- Identification of ecological sensitive receptors.
- Evaluation of the significance of potential impacts on sensitive receptors
- Recommendations for mitigation measures and monitoring (if applicable).

4.2.1 Marine ecological survey and assessment

For coastal engineering projects in PICT, a marine ecological survey of the beach, reef platform, reef edge, reef crest and reef slope is likely to be essential. That is, it should cover the project footprint and area of influence (based on the coastal process and water quality assessment). This could include offshore mooring sites. Such surveys will need to be undertaken through a combination of walking, wading snorkelling and diving (depending on conditions). A manta tow approach (via a boat) may be used where sea conditions are rough.

The focus of the survey should be on the benthic substrate and species (and in particular corals), fish, macroalgae, invertebrates and (in some cases) cetaceans; and threatened and protected species.

4.2.2 Terrestrial ecological survey and assessment

A terrestrial habitat survey is also likely to be required, dependent on the scope of the project, and should typically focus on the identification of endemic habitats and species – flora, fauna and avifauna.

4.3 Socio-economic Resources

4.3.1 Context

In the Pacific, population, education, health and health infrastructure; livelihoods, subsistence and incomes; land tender, ownership and use; transport, energy, water supply/sanitation and waste management infrastructure; and cultural resources (particularly grave sites at the coast) are all of relevance. Each island typically has its own governance structure and expectations regarding gender and respect, that need to be understood in the development of social impact mitigation strategies.

Although coastal engineering projects may affect air quality and the noise environment of PICT, baseline air quality and noise surveys are generally not warranted where air quality is expected to be very good and noise levels limited (i.e., the baseline is easy to quantify).

UXO desktop, Niutao, Tuvalu

Tuvalu was used as a staging base for US aerial attacks in the Battle of Tarawa in Kiribati during World War II. Bomber bases were established on Funafuti, Nanumea and Nukufetau, being the only islands big enough to accommodate them. Funafuti, Nanumea and Nui were the only islands to be bombed.

Milsearch undertook historical desk-top research into military activities that may have resulted in the presence of UXO on Niutao Island. This found that VMF-422 squadron ditched the USMC F4U-1D Corsair aircraft onto Niutao Island’s western foreshore. However, it was determined that this does not represent a UXO risk to the island or the Tuvalu Outer Island Maritime Infrastructure Project.

Historical records indicate that Niutao Island was not impacted by any other event able to generate remnant World War II UXO contamination on the island, or its immediate surrounds. Further risk assessment was not considered to be necessary nor recommended.

4.3.2 Heritage, or cultural, assessment

The purpose of a heritage impact assessment is to identify and evaluate the potential impacts of a proposed development on the cultural significance of a place. Typically, a heritage impact assessment builds on the work of an assessment of significance and a should take account of any policies aimed at conserving the heritage or cultural value in the future. UXO assessments can also be relevant.

In line with EIA methods, heritage assessment follows a similar process of:

- understanding the environment through observations and data collection;
- analysis of available information;
- identification and evaluation of potential impacts; and,
- recommending mitigation measures.

5 Typical Impacts & Mitigation Strategies

Coastal engineering projects in PICT have the potential to generate a range of impacts, the significance of which that need to be assessed through EIA. As detailed in Section 3, there are several different forms of coastal engineering that are relevant to this guide, including excavation and dredging, reclamation, breakwaters, seawalls, groynes, beach nourishment, planting and stabilisation, creation/adaptation of waterways and wetlands, coral gardens and so on. However, many of these activities have the same potential effects, so the approach adopted here aims to link activities to potential outcomes and then consider those outcomes (or impacts) and possible mitigation measures.

5.1 Changes to Coastal Processes

This includes changes to hydrodynamic (waves, tides, and currents) and morphodynamic (sediment transport) processes. Such changes can have direct effects on coastal features (geomorphology), e.g., beaches) and indirect effects on water quality and ecology, which may cause impacts. The prediction of effects on coastal processes, like the design of coastal infrastructure, needs to take account of the implications of projected future climate change parameters for the Pacific.

5.1.1 Potential effects

Development activities that have the potential to effect coastal processes include, but are not necessarily limited to:

- Engineering activities that directly alter the morphology of the coastal zone, resulting in changes to sediment sources or sinks (and the loss or gain of habitats), such as -
  - reclamation/excavation of the coastline
  - capital and maintenance dredging (and dredged material disposal)
  - the creation of shipping/boat channels
  - beach nourishment (sand bypassing).
- Associated impacts may include -
  - interruption of longshore sediment transport
  - changes in erosion/deposition patterns, and coastal features
  - collapse of an exposed beach profile due to erosion during construction (prior to restoration)
  - loss or dispersion of excavated material stockpile on the beach
  - changes in the structure of marine habitats and communities (see Section 5.3).

Pacific Climate Change

For the period to 2100, the Pacific Climate Change Science Program of Australia projections (2011) indicate that the following are projected to continually increase:

- Surface air temperatures and sea temperatures.
- Annual and seasonal mean rainfall.
- The intensity and frequency of extreme heat days and rainfall days.
- Ocean acidification.
- Mean sea level.
- Coral bleaching.

By contrast, in some parts of the Pacific, such as in the south-east Pacific Ocean basin, the frequency of tropical cyclones and incidents of drought may decrease.

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- Infrastructure that alters wave energy and tidal currents, such as -
    - breakwaters, seawalls, or revetment walls (rock armour)
    - wharfs, jetties, boat ramps or marinas
    - reclaimed areas.
- Associated impacts may include -
    - effects on navigation
    - interruption of longshore sediment transport
    - changes in erosion/deposition patterns, and coastal features
    - changes in the structure of marine communities.

- Infrastructure or engineering activities that interrupt tidal flows/currents or causes a reduction in water exchange, such as -
    - marina or harbour water bodies
    - canal developments
    - alteration of river mouths or deltas.
- Associated impacts may include -
    - changes in water quality
    - retention of nutrients and other contaminants
    - saltwater intrusion or coastal inundation.

5.1.2 Mitigation strategies

To mitigate the effects of a project on coastal processes a proponent may employ the following mitigation strategies:

- Careful site selection and design of the development layout should minimise effects on coastal processes, particularly sediment transport, and provide for climate resilience. Key to the development of such a design is numerical modelling of the predicted effects and testing alternatives; leading to the selection of a preferred project option, which minimises physical impacts and consequential biological impacts.
- Careful planning of works such that only short, excavated sections are exposed at one time and the works completed between periods of high tide or, if sufficiently above high tide mark, before any advancing weather system approaches the island (i.e., minimising the period that excavated areas are left unprotected). All excavated material to be immediately removed to a designated storage area. No excavated material to remain on the beach or reef flat between tides.
- Minimising the clearing of any vegetation along the shoreline of a project site and/or incorporating bioengineering (planting) solutions (or where necessary a retaining wall) into the design.
- Clear identification of a designated beach access route, to minimise damage.
- Pre and post work hydrographic surveys to ensure that currents, water depths and sediment transport regimes are unaffected or within the modelled parameters, linked to a management response should noncompliance be determined.

Ebeye Coast Protection, RMI

To provide protection against wave induced erosion and flooding due to King tides and storm surge, 10 seawall concepts were initially developed and the top four shortlisted through an MCA process on which key stakeholder and community feedback was sought. The shortlisted options are to be assessed against four weighted categories as follows:

- Engineering viability – 35%
- Affordability – 20%
- Social implications – 30%
- Environmental implications – 15%.

The MCA process adopted allowed for options that were not viable (e.g., impacts on critical habitats) to be ruled out early and for greater focus on suitable options.

- Timing works to ensure that they do not occur at times that may lead to greater impacts, e.g., during bad weather and in the cyclone season.
- Beach nourishment or sand bypassing (e.g., from down to upstream) may itself be a mitigation measure is sediment transport is interrupted.

5.2 Changes to Marine Water and Sediment Quality

The term ‘environmental quality’ refers to the level of contaminants in water, sediments, or biota, or to changes in the physical or chemical properties of water and sediments relative to a natural state.
The clear, largely unpolluted waters of the Pacific marine environment, and the biota they support, are highly valued by the community for active and passive recreational opportunities and because they provide economic value by supporting subsistence and commercial fishing, aquaculture, and tourism. Coastal engineering projects can lead to a lowering of environmental quality.

5.2.1 Potential impacts

The different types of impacts associated with a reduction in marine water and sediment quality include direct toxicity due to the release of natural or synthetic chemicals, bioaccumulation/bio-concentration of contaminants to toxic levels, deficiency (e.g., reduced oxygen), physical effects (e.g., increased light attenuation / turbidity), bio-stimulation effects (e.g., algal blooms), or exposure to pathogenic organisms.

The coastal engineering and development activities that have the potential to impact on marine water and sediment quality include, but are not necessarily limited to:

- Dredging (excavation) and dredged material disposal can increase turbidity, suspended sediment concentrations and sediment deposition rates, alter the physical characteristics of adjacent sediments, mobilise contaminants contained within the sediments, and reduce water clarity and light over quite large areas. All of which can have significant consequences for corals, invertebrates, fish and shellfish and marine mammals.
- The placement (or dumping) of rocks and other material for the construction of breakwaters, groynes, and rock walls, can increase turbidity and reduce water clarity and light availability.
- Discharges, such as wastewater, can release natural and synthetic toxic chemicals to the environment, change the physical and/or chemical characteristics of the receiving waters, enrich receiving water and sediment with nutrients, or release disease causing pathogens.
- Ports, marinas and harbours generally contain higher levels of contaminants than other areas due to the presence of anti-foulants on vessels, corrosion inhibitors, and other chemicals in an environment with reduced water exchange and flushing.
- Unplanned releases of chemicals, hydrocarbons or other contaminants associated with activities such as the transfer and storage of bulk shipping commodities, construction activities (including excavators and other plant working in the marine or coastal environment, and concrete pours), and accidental collisions or ship groundings. Generally, if a site and construction plant are well managed and maintained, these have a low probability of occurrence but, if they do occur, the consequences for marine environmental quality can be severe.

5.2.2 Mitigation strategies

To mitigate the potential impacts of a project on marine environmental quality a proponent may employ the following mitigation strategies:

- Careful site selection and design of the development layout can minimise impacts on marine environmental quality. That is, impacts can be minimised by identifying, and avoiding, areas that contain potential contaminants (sites of historical spills or industrial use).
- The development of a Dredging Plan, often informed by a hydrodynamic and sediment transport model to quantitatively assess the advection-dispersion of fine sediment plumes associated with the proposed dredging. It is notable, however, that such plume modelling will often overestimate the dredging production rates that are achievable on remote Pacific islands working with excavators limited to low tidal conditions. A Dredging Plan may -
  - Limit dredging to lower tidal conditions.
  - Preclude dredging (or in-water work more generally) during bad weather.
  - Specify monitoring requirements (e.g., images of plume movements, details of seas conditions and wind and, if of sufficient concern, measurements of suspended sediment levels) and response protocols (e.g., if the responsible Environment Officer considers the plume density or extent to be at a level that could be having a detrimental effect on coral on the reef crest, then the dredging should be adapted to reduce the plume density or extent; which may involve reducing dredging intensity).
- Careful management of in-situ concrete pours in avoid spills and egress into the water body. Mass concrete pours undertaken on a reef platform must be undertaken in calm, low tide conditions, with the area of works temporarily bunded. Such activities should be monitored by the Environment Officer and any spills cleared immediately.
- An EMMP that focuses on the key threats posed by the project to marine environmental quality and the pathways by which those threats could cause environmental protection to be compromised. Specifically, the EMMP should include -
  - Measures to minimise sediment release (in the appropriate circumstances, i.e., where currents are low, this may include silt curtains; see **Figure 4**).
  - Measures to ensure the release of contaminants from construction activities, such as concrete pours, and from plant or other construction equipment does not enter the water, e.g., ensuring that all equipment to be used below the highwater mark is in sound mechanical condition and free of any leaks of any fluid. Pre-start inspections should always be carried out and recorded. Plant should also only be operated by certified and experienced operators.
  - An immediate response protocol and management strategy if unexpected contamination is uncovered during construction.
- A Spill Response Plan. This will often be a subplan forming part of the EMMP.

5.3 Benthic Communities and Habitats

Benthic communities are biological communities that live in or on the seabed. These communities typically contain light-dependent taxa such as algae, seagrass, mangroves and corals, which obtain energy primarily from photosynthesis and/or animals, such as molluscs, sponges and worms, that obtain their energy by consuming other organisms or organic matter. Benthic habitats are the seabed substrates that benthic communities grow on or in. They can range from unconsolidated sand to hard substrates such as limestone, igneous rock or coral reefs, and occur either singly or in combination.

Benthic communities and habitats play an important role in maintaining marine ecosystems and associated ecological services. Benthic communities are important for the maintenance of biodiversity through provision of diverse habitat, refuge, and food. Some of these habitats are vital nursery areas for various marine fauna species and may also provide essential food resources for large marine mammals, such as dugongs and turtles. Benthic primary producer habitats form the foundation of marine food webs which, in turn, support productive and economically important fisheries. They are also capable of dissipating wave and current energy, which helps protect shorelines and coastal infrastructure.

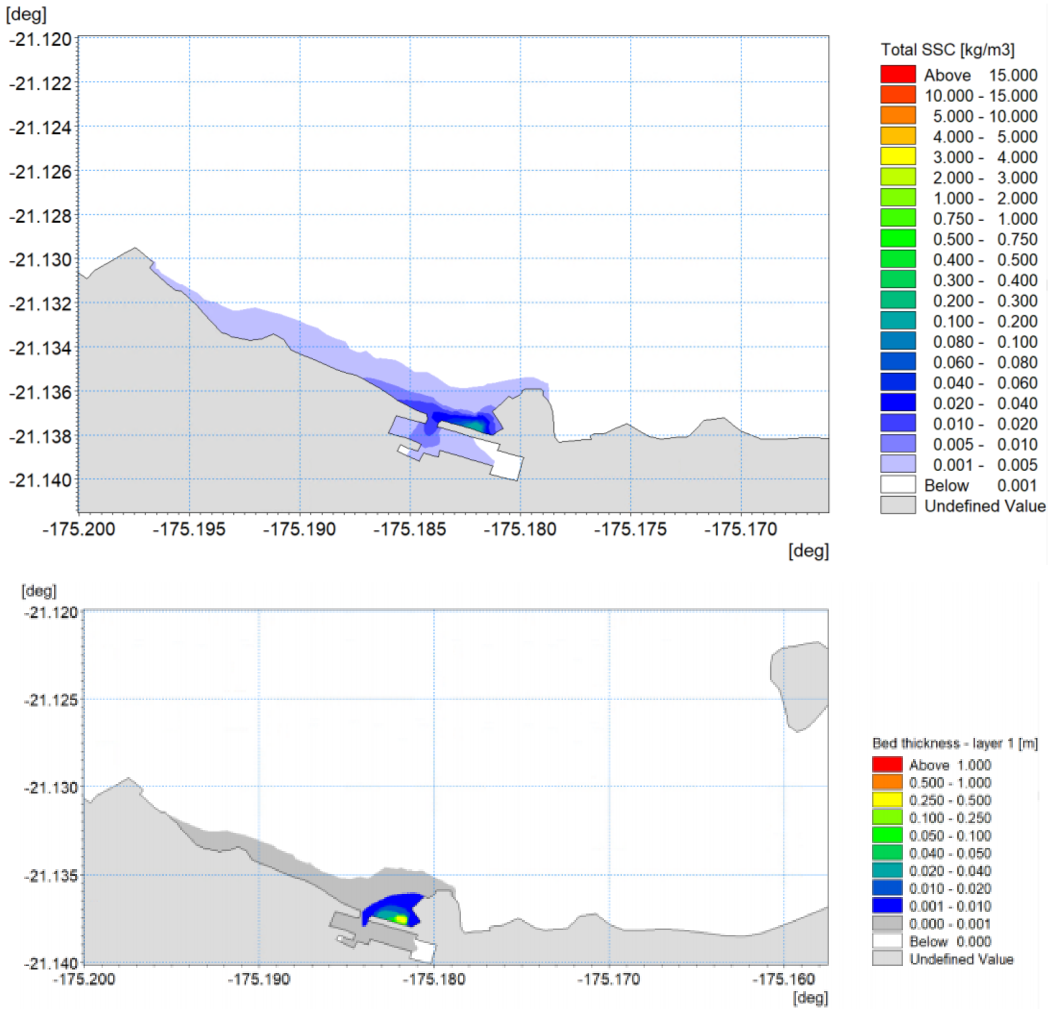

Figure 4: (a) Maximum surface total suspended solids (one-month simulation) without a silt curtain and (b) sediment deposition thickness (two-month simulation) with a silt curtain, Nukulaelae Port, Tonga

5.3.1 Potential impacts

Impacts on benthic communities and habitats can be both direct (e.g., dredging or reclamation of habitat), which are often irreversible, or indirect (e.g., shading or smothering), which may be reversible once the pressure is removed (e.g., in dredged channels, macroalgae communities, sponges, ascidians (sea squirts), other invertebrates and even corals may re-establish (or establish) in time). Impacts from most development activities include both direct and indirect impacts to varying degrees and almost all significant marine and coastal development proposals will result in some loss of important benthic communities and/or habitat.

The development activities that have the potential to impact on benthic communities and habitats include, but are not necessarily limited to[3]:

- Dredging and excavation, both through the direct take of benthic habitat and indirectly through increased turbidity (suspended sediments that reduce light availability for photosynthesis) and sedimentation, and the potential mobilisation of contaminants contained within the sediments.

[3] Marine sea cage aquaculture can also directly impact on benthic communities and habitats through anchoring systems or shading by the cages. Indirect impacts can result from the deposition of organic waste and other contaminants causing changes in environmental quality.

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- Placement of rocks and other material (including concrete blocks and sheet piles) for the construction of infrastructure such as harbours, breakwaters, groynes, bridges and rock walls, which destroys benthic habitat and has the potential to indirectly impact adjacent benthic communities and habitats through increased turbidity and by altering wave and current energy patterns. Piled structures (such as jetties) are less likely to have such indirect effects but will cause habitat loss in the footprint of the piles and shading.
- Construction of barriers to tidal movement (e.g., harbour and seawalls, berms, causeways) can potentially change the hydrodynamics and flushing of estuaries and embayments, causing mortality of benthic communities and loss of habitat through changes in inundation patterns and salinity.
- Wastewater discharges (domestic wastewater, industrial waste, cooling water and tail-water from onshore dredge spoil disposal) all have the potential to affect the quality of water, sediment and biota in the vicinity of the discharge and impact on the health of benthic communities or, in extreme cases, cause the mortality of benthic communities.
- The activities of marine vessels and construction plant and equipment (spills are covered in Section 5.2).
- Land-based construction works. In the absence of proper sediment and erosion controls heavy rainfall or wind may results in sediment being mobilised and transported to the ocean.

In assessing the direct loss of benthic communities and habitats, important factors to consider are percentage coverage (i.e., what proportion of the affected area contains habitats of interest), the unique attributes of the habitats and communities they support (are they rare, endangered or threatened), protected status, and potential for recovery (if any). Vulnerability (or sensitivity) to the predicted effect and ability to recover are important considerations related to indirect effects.

5.3.2 Mitigation strategies

To mitigate the impacts of a project on benthic communities and habitats a proponent may employ the following mitigation strategies:

- Careful site selection and design will minimise impacts to benthic communities at the site by identifying, and avoiding, areas that contain sensitive receptors, such as important ecological communities (e.g., corals). This may require some adjustments to the siting and orientation of aspects of the project at the planning stage. The design should meet it objectives (its need), while at the same time minimising its footprint vis-à-vis benthic communities.

Deflagration

Traditional high order high order blasting can be extremely damaging to coral colonies, affecting fish populations and coastal communities. Hence, the use of explosives is largely prohibited in PICT. But coral pinnacles and rock heads on the reef crest can be difficult to remove using a barge or excavator due to the wave climate. An alternative approach is deflagration - low order detonation, where the active material is burnt and expands without exploding. Vibration, noise and an air pressure blast will occur, but their levels and duration will be significantly lower and shorter, and the spread of the residual material will be less as compared to traditional blasting.

Deflagration has been used in Port Kembla, Australia, and Vanuatu (to remove dead coral heads) and is proposed for use in Tuvalu.

Issues relevant to the use of deflagration include geotechnical information (rock strength); bathymetry; the quantity of material to be removed; and access to the site. The cartridges need to be drilled into the coral layer, so consideration needs to be given to how the drilling will be undertaken (e.g., are expert divers available and diving conditions safe?) and the need and means to remove the broken coral.

To calculate the impact of such an approach, percentage coral coverage needs to be considered (which is typically higher on the reef slope and crest as compared to the reef edge and flat).

- Where relevant, projects should be timed to avoid key periods for sensitive receptors (e.g., breeding periods). For example, activities that increase turbidity should be timed to avoid important flowering and growth stages for marine plants.
- Working corridors and areas, e.g., on the reef platform, should be minimised and defined, and the movement of construction vehicles limited to these areas. Designated anchoring zones (avoiding corals) should be defined.
- This detail should be set out in a site-specific Method Statement for the proposed works that clearly identifies the viability of the approach proposed and how impacts will be avoided or minimised (e.g., the use of a floating platform to excavate across the reef crest rather than a temporary bund).
- An EMMP that includes -
  - Monitoring to ensure the impacts to benthic communities are limited to those deemed acceptable, for example water quality monitoring to minimise the impacts to benthic communities outside the footprint of the works and surveying to determine if the works, workboats etc, are avoiding identified significant communities.
  - Standard, best practice erosion and sediment controls for land-based construction (e.g., appropriate drainage around stockpiles and containment bund for hydrocarbons), including appropriate management plans for any specific contaminants (if present).
- Where impacts cannot be mitigated, compensatory measures may be explored, such as -
  - Relocation of communities, such as corals or seagrass, to other unaffected areas.
  - Restoration of habitats upon completion of the construction phase (if site conditions remain suitable post-construction), e.g., coral or seagrass replanting. Such initiatives need to be supported by relevant experience and over time, often after the projects works have been completed.

5.4 Marine Fauna and Avifauna

Marine fauna are highly diverse and range in size from microscopic zooplankton to the blue whale. Marine fauna that live their entire life in the ocean include sharks, whales, dolphins, dugongs, sea snakes, most fish, crustaceans and plankton. Marine fauna that either leaves or enters the ocean for breeding or resting purposes, includes turtles, seals and sea lions, penguins, and crabs. While animals such as sponges and corals that are attached to the seabed are also marine fauna, they are typically considered to be part of benthic communities and habitats. Marine avifauna are seabirds, which are considered in parallel with marine fauna below.

5.4.1 Potential impacts

Development activities that have the potential to have an impact on marine fauna include, but are not necessarily limited to:

- Activities that change the characteristics of the marine and coastal environment, including -
  - Dredging, excavation and the placement of rock, through increases in turbidity and the mobilisation of contaminants (if any) located within the sediment.
  - Construction of harbours, breakwaters, causeways, walls and other marine infrastructure that has the potential to change marine currents and other coastal processes.
  - Ports, harbours and marinas that effect water quality within confined water bodies and its exchange with the broader marine and coastal environment.
  - Outflows and discharges from construction sites (including accidental discharges), commercial and industrial development and aquaculture operations.

- Activities that cause underwater noise, including from pile driving, rock dumping, dredging, vessel movements and seismic exploration. Underwater noise can negatively impact marine fauna through physical injury or causing physiological effects / avoidance behaviour (albeit the latter will generally be intermittent, short term and localised).

- Infrastructure lighting. Inappropriate lighting either at the shore or on vessels that can alter behaviours, e.g., turtle behaviour during the nesting season.
- Vessels movements during construction and the operation of ports, harbours and jetties have the potential to injure or kill marine fauna, through collisions, or may result in avoidance behaviour. Marine turtles and cetaceans (whales and dolphins) are particularly susceptible to harm from vessel strike.
- The import of plant, equipment, and materials for construction, which has the potential to introduce invasive marine species (such as the crown of thorns starfish *Acanthaster plancii* and Brown macroalgae *Sargassum spp.*) or disease through insufficient biosecurity (cleaning and inspection of marine plant and equipment) and ballast water exchange.
- High volume seawater intakes (e.g., desalination and cooling water intakes) can entrain or trap adult and juvenile marine fauna as well as large numbers of planktonic larvae and result in mortality.

5.4.2 Mitigation strategies

To mitigate the impacts of a project on marine fauna a proponent may employ the following mitigation strategies:

- Careful site selection and design. Impacts can be minimised by identifying, and avoiding, areas that support sensitive receptors, such as important habitats or feeding and nesting grounds for marine fauna.
- Projects phasing to avoid key times for sensitive receptors. For example, activities that restrict fish passage should be avoided during migration and spawning seasons.
- Marine ‘go slow’ zones around construction sites to reduce the risk of boat strike and reduce noise related effects.
- An EMMP that includes -
    - Equipment maintenance to ensure good working order and the use of proper sound controls where appropriate and practical (e.g., mufflers, propeller shrouds and tuned propellers and drive shafts).
    - Monitoring to ensure the impacts to marine fauna are limited to those deemed acceptable (see Section 5.3.2), that sound-generating equipment is switched off when not in use, and that appropriate weed and pest control measures are in place.
    - Measures/a plan to support any marine fauna or avifauna that are trapped or injured by the works.
    - Thorough biosecurity measures (such as phytosanitary certificates issued in the country of origin prior to shipment of plant and aggregate) and compliance checks to ensure pest species are not introduced by the works. This should include restrictions on ballast water discharge within 5km of the coast (with confirmation via logbooks).

Niutao Small Boat Harbour, Tuvalu

A consent condition on the project is that any coconut crabs *Birgus latro* (a locally important species and food source) living in the vegetated parts of the beach need to be relocated (in conjunction with the local Conservation Officer) prior to clearance of the vegetation, and information on size, gender, number, and location needs to be provided to the Department of Environment. This is to be achieved via an immediate pre-works survey to identify coconut crab habitats (and active sea bird nesting sites).

For active sea bird nesting sites, a buffer is to be established between construction activities and the nest to minimize noise and disturbance and should be in effect until the nest is no longer active. The buffer should be as large as it can be and at least 10m. The Contractor shall not destroy nests, eggs, or nest sites, including trees.

- Education for skippers of construction barges and workboats on how best to avoid boat strikes, what to do during vessel interactions with marine fauna and reporting of boat strikes or fauna interactions.
- The minimisation and shielding of lighting, and use of directional lighting (while meeting health and safety requirements).

- Where impacts cannot be mitigated, compensatory measures may be explored, such as -
  - Relocation of communities or individuals, to other, unaffected areas.
  - Restoration of habitats upon completion of the construction phase (if site conditions are still suitable), e.g., mangrove seagrass replanting.

5.5 Changes to Terrestrial Water and Sediment Quality

Although not the central focus of this guide, changes to terrestrial water and sediment quality can arise due to coastal engineering projects and effect the coastal environment.

5.5.1 Potential impacts

Development activities associated with coastal engineering projects that have the potential to impact on terrestrial environmental quality include, but are not necessarily limited to:

- clearing of deep-rooted remnant native vegetation in areas prone to salinity and erosion (see Section 5.1)
- waste rock and tailings (dredged arising) disposal
- disturbance to acid sulphate soils and land use practices with the potential to cause soil contamination
- production of construction waste.

The management of construction waste from maritime projects can have a significant environmental impact on small remote island communities. There is generally very little ability or infrastructure to effectively manage solid waste. While waste pits are used, there are potential problems associated with leachate entering groundwater, which is often already subject to degradation.

Hydrocarbons (fuel, lubricants) and marine paints and solvents stored, dispensed and used during construction works by vehicles, plant and equipment pose a potential hazard to the marine environment, as well as the subsurface freshwater lens on the island if leakage or spillage occur. Large quantities of hydrocarbons are often required to be stored on remote islands for the duration of coastal development projects, due to the logistical challenges and the long supply line. Hence, extreme care is required to ensure there are no accidental spills and proper storage.

Because of space and resource constraints, dredged material often needs to be stockpiled on island for harbour and/or seawall projects, ahead of crushing and its use in the structure. If such stockpiles are not properly managed, impacts on soils, vegetation and water quality can occur.

5.5.2 Mitigation

To mitigate the impacts of a coastal engineering project on terrestrial (and consequently marine) environmental quality, a proponent may employ the following mitigation strategies:

- Careful site selection and design, e.g., avoiding areas that contain potential contaminants or sensitive receivers. Additionally, the project should be staged to avoid large areas of excavation being exposed at the same time, to minimise the potential for erosion.
- A requirement for all hydrocarbons to be stored either on the supply ship, barge or in a dedicated land-based facility. The proposed location of the shed should be selected in conjunction with the island elders to ensure it does not impact any houses or water supplies.

- A requirement for all inorganic and solid waste generated by the construction (including waste hydrocarbons, steel, formwork hoses, tires etc.) to be removed from the island environment. There may be some limited exceptions, for example, where surplus concrete or aggregate can be utilised for the construction of community facilities. Exceptions such as these will need to be agreed with the island elders in advance.
- Agreement on the location of any material stockpiles with the island elders in advance and ensuring that they are stored in bunded areas or in a controlled and well-managed manner.
- Installation of on-site toilet facilities (including separate, secure facilities for women) with an appropriate self-contained sewage tank.
- Composting of all green and organic wastes generated by the contractor to assist soil improvement for communal food crops or use as pig food.
- An EMMP that focuses on the key threats posed by the project to terrestrial environmental quality and the pathways by which those threats could cause environmental protection outcomes to be compromised. Specifically, the EMMP should include -
  - Comprehensive site induction for all personnel involved in the project, with specific attention on, e.g., the sensitive atoll or reef environment and waste/spill management.
  - All personnel involved in handling dangerous goods to be trained and inducted in the handling, emergency procedures and storage requirements for different types of substances.
  - Measures to ensure contaminants released from plant or other construction activities do not enter any water bodies. Including –
    - where fuel is stored on land, it will be stored in dedicated areas in sealed tanks placed within a concrete bund that has 110% of the capacity of the drums for storage
    - storage areas to be located at least 50m away from the marine environment and fully secured and locked when not in use
    - smaller volumes of hazardous substances to be contained within a metal storage locker within the storage shed
    - quantities of marine paint to be limited to no more than two litres at any one time contained within a larger volume drip tray
    - lined pits to separate oil and water to be installed near any workshop or maintenance shed to prevent leaching of hydrocarbons into the water table
    - vehicles and machinery to be refuelled by authorized and trained personnel only in designated areas and not over water; drip trays to be used during refuelling or servicing
  - Spill kits to be available in all land and sea works areas.
  - A protocol for dealing with unexpected contamination if uncovered during construction.
  - A Waste and Spoil Management Plan and a Spill Response Plan (procedures for cleaning up and reporting accidental spills).

5.6 Terrestrial Flora

Groupings of different flora (vegetation) are patterned across the landscape in response to environmental conditions. A decline in the extent and condition of vegetation may precede the loss of its species and provide an indicator of the (poor) health of other elements of the environment. Although not the central focus of this guide, changes to terrestrial vegetation can arise due to coastal engineering projects and effect the coastal environment.

5.6.1 Potential impacts

The degree of disturbance and the biology of the vegetation involved will determine the severity of direct impacts on flora. The most severe will be the permanent alteration of substrate and habitat (such as building a road, a passenger building or removing the landform upon which a species occurs), while some flora may readily recover from temporary clearing. Many coastal engineering projects will involve the removal of vegetation for the construction camp, laydown and storage areas, with the loss of protective ground cover, habitat and shade.

Indirect impacts on flora include, but are not necessarily limited to:

- fragmentation or isolation of populations/occurrences
- effects on the habitat that supports it
- effects on other species with important ecological functions, e.g., pollinators, seed dispersal vectors, essential symbiotic fungi
- introduction or promotion of weeds and/or disease, and temporary impacts such as fire
- altered hydrology, including an increase or decrease of the groundwater level and alteration of surface water flow.

5.6.2 Mitigation strategies

To mitigate the impacts of a project on terrestrial flora a proponent may employ the following mitigation strategies:

- Careful site selection and design, avoiding areas that contain sensitive receptors. Formerly cleared land should be selected preferentially, where suitable, for supporting infrastructure. Buildings and/or shelters should not be located closer than 20m to the foreshore.
- Large single trees should be retained where practicable to provide shade and amenity value. However, individual trees should not be retained where they are exposed to the influence of winds, impacting their stability, where the root plate is damaged during site preparation or where they are affected by disease. Trees to be retained should be clearly marked.
- An EMMP that includes monitoring to ensure the impacts on are limited to those identified at the design stage, for example tree protection plans to ensure retained trees/vegetation are not impacted by construction activities nearby by causing issues such as root die back and compaction of the drip zone.
- Where impacts cannot be mitigated, compensatory measures may be explored, such as relocation of communities (endangered plants) to other unaffected areas and restoration of habitats upon completion of the construction phase (if site conditions remain suitable post-construction).

5.7 Effects on Air Quality

Air quality is the chemical, physical, biological and aesthetic characteristics of air. Maintaining good air quality and minimising emissions protects human health and amenity, as well the broader environment.

5.7.1 Potential impacts

Coastal engineering projects have a limited ability (by contrast to power and industrial projects) to adversely influence air quality. In general, they will have no operational effects and effects will be limited to dust and exhaust emissions in the construction phase, generated by construction machinery, excavation and material disposal, pile

Nui Small Boat Harbour, Tuvalu

Given the proximity of the works to the main village, the potential was evident for adjacent residents to be affected by a degradation of air quality and dust. So, an air quality assessment was undertaken with the objective of determining where construction plant should be located to minimise the effects of dust and particulate matter (PM_{10}). The study area was defined as human receptors within 350m of the site and 50m of the haul route and ecological receptors within 50m of the site / haul route. The predicted inputs were demolition; earthworks; crushing, concrete batching and stockpiling; and track-out activities. The location of highly sensitive receptors was determined relative to predicted dispersion / predominant wind direction. Based on this it was recommended that the crusher was not located to the north of the village, as winds would be more likely to disperse dust and particulates across the village.

driving, vehicles, and mobile generators, as well as crushing dredged material for aggregate and concrete batching plants.

5.7.2 Mitigation strategies

To mitigate the impacts of a project on air quality a proponent may employ the following mitigation strategies:

- Careful site selection and design to avoid the proximity of certain activities (e.g., crushing and batching) to areas that contain sensitive receptors, such as important habitats or population centres. In the case of ports, green port initiatives to reduce emissions could be specified in the design.
- An EMMP that includes provisions for -
  - The use of fully maintained vehicles and diesel equipment that have been certified as compliant with local air quality legislation prior to transhipment to the project site.
  - Avoiding idling of vehicles when not in use and unnecessary operation of equipment.
  - Dust control through –
    - spraying haul routes and excavation areas, strictly using rain or seawater
    - imposing a speed limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads
    - limiting or suspending excavation and other dust producing activities during periods of strong onshore winds when working adjacent to village buildings and houses
    - covering and bunding stockpiled materials where feasible (e.g., using mulches)
    - ensuring bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery
    - considering the erection of screens around dusty activities.
  - Recording and resolving all dust and air quality complaints and exceptional incidents.
  - Undertaking daily inspections of nearby receptors to monitor dust when activities with a high potential to produce dust are being undertaken, with cleaning to be provided if necessary.

Apia Green Port

The vision for Apia Green Port has two parts:
- to optimise energy efficiency, adopt environmentally sustainable practices and develop in a sustainable manner; and,
- to be operationally efficient, safe and resilient to future climate change and commercial challenges.

Its priorities are to:
- measure and reduce annual use of electric power and diesel; and,
- measure and improve waste and wastewater management (from vessels and on the yard), reuse/recycling, and water use.

5.8 Noise Effects

Noise pollution is unwanted or excessive sound that can have impacts on human health, wildlife, and environmental quality.

5.8.1 Potential impacts

British Standards set ‘reasonable’ daytime, night-time, and evening/weekend noise thresholds as 65 dB, 45 dB and 55 dB respectively. Noise pollution will arise due to the construction of coastal engineering projects, e.g., handling rock for seawalls, piling for jetties, dredging and hydraulic rock breaking (around 78 dB at 10m), crushing (around 82 dB at 10m), concrete batching, water and fuel pumps, generators (around 61 dB at 10m) and site vehicles. The operation of some facilities, such as ports, can also lead to operational noise, particularly in generally quite (low noise) Pacific environments. However, for coastal engineering projects, noise effects are largely associated with the construction phase.

Exposure to excessive or prolonged noise has been shown to cause a range of human health problems, ranging from stress and fatigue from lack of sleep, poor concentration, productivity losses, and communication difficulties, to more serious issues such as cardiovascular disease, cognitive impairment, tinnitus, and hearing loss.

Noise pollution also has a negative impact on wildlife by reducing habitat quality, increasing stress levels, and masking other sounds. Chronic noise exposure is especially disruptive for species that rely on sound for communication or hunting. For example, bird species that rely on vocal communication, bats and owls, and prey species that rely on noise to detect predators may have decreased patterns of foraging, reducing growth and survivability. Bird species and nocturnal animals haven been shown to avoid areas with noise pollution. Reductions in bird populations and foraging activities can, in turn, negatively impact seed dispersion, affecting ecosystem services and diversity.

5.8.2 Mitigation strategies

To mitigate the noise impacts of a project a proponent may employ the following mitigation strategies:

- Careful site selection and design to minimise noise impacts (as for air quality).
- Screening noisy activities where the noise impact is predicted to be significant and this is viable (e.g., it may be possible to screen a crusher or batching plant but, typically, it will not be possible to screen excavation activities).
- Time works to avoid sensitive periods, such as night-time[4], Sundays, cultural events, and fauna migrations.
- An EMMP that includes provisions for -
  - Managing noise by ensuring that high noise generating activities are undertaken during daylight hours.
  - Appropriate staff training to avoid unnecessary noise emissions (unnecessary revving of engines, avoiding reversing, driving within the speed limit, shutting down equipment between use, reporting and repairing defective equipment).
  - The use of modern, quiet construction equipment, in accordance with guidance, and proper maintenance / regular inspection.
  - Liaison with the island leaders to minimise disruption to church services, schools, health clinics and other sensitive receptors.
  - Undertaking noise monitoring to ensure applicable noise standards are met. This may be informal monitoring through a grievance redress mechanism (GRM).

5.9 Other Societal or Community Effects

Tropical small island nations in the Pacific and other parts of the world are facing increasing social and ecological change resulting from development, population growth, and climate-related changes. These are affecting the livelihoods and survival of coastal communities. Although most coastal engineering projects are designed to improve conditions on the islands (i.e., provide essential transportation infrastructure and coastal defences), they also have the potential to cause harm.

5.9.1 Potential impacts

Activities associated with coastal engineering projects that have the potential to affect communities include, but are not limited to:

- Activities that disturb the ground in a way that may impact sites of cultural and heritage significance.
- Activities that may impact amenity by -
  - Generating noise or vibration in proximity to sensitive premises (see Section 5.8).
  - Generating dust (see Section 5.7).

[4] *For land based works, generally this will be possible, but working at night may not be able to be avoided (without significantly extending the duration of the construction phase) for works that are tidally constrained.*

  - Increasing traffic and nuisance.
- Activities that may impact aesthetic values, such as -
  - large scale quarry or mining activities
  - major tourism or other developments in or adjacent to natural areas.
- Construction projects that involve an influx of foreign and non-local workers to remote communities, which introduces risks associated with cultural insensitivity, child protection and communicable diseases, included sexually transmitted infections (STIs) and COVID-19. Communicable diseases common in PICT include chlamydia, syphilis and hepatitis B. HIV/AIDS is also prevalent.
- Activities that have hygiene and sanitation impacts through use of the island's water supply, potentially causing water shortages, and an absence of proper disposal procedures for water and wastewater used by workers and/or for construction activities (see Sections 5.2 and 5.5). Potable and fresh water is a scarce commodity on many outer islands, where groundwater is known to be increasing in salinity.
- Activities that have a health and safety risk. Construction on remote islands carries significant risk to construction workers and the community if it is not appropriately managed. Relatively minor injuries may have life threatening consequences due to the difficulty of getting access to appropriate and timely medical treatment.
- Dredging activities that may cause Ciguatera – a foodborne illness caused by eating certain reef fish whose flesh is contaminated with a toxin made by dinoflagellates, such as *Gambierdiscus toxicus*. These dinoflagellates adhere to coral, algae and seaweed, where they are eaten by herbivorous fish which in turn are eaten by larger carnivorous fish. Exacerbation of the effects of Ciguatera outbreaks have been linked to reef blasting in Tuvalu (Niutao in 1989 and Nui in 1988).

5.9.2 Mitigation strategies

To mitigate the societal impacts of a project a proponent should employ the following mitigation strategies:

- Careful site selection and design to minimise adverse effects and maximise benefits to the community. Suitable sites for the works and construction compounds should be approved by the village elders to ensure these are not on or near any heritage sites, areas of cultural significance or result in any damage or removal of indigenous vegetation of high ecological or social value.
- Timing works to avoid sensitive periods of the year, such as cultural events.
- The development of a chance (or unexpected) finds protocol should, for example, graves, cultural and heritage objects or artifacts (or UXO) be identified during the works. For activities that may occur in areas where cultural resources could be present, procedures should be specified for identifying and avoiding impacts on cultural property, including –
  - Consultation with the village elders and community to identify known and possible sites linked to project activities.
  - Cessation of work should a site of possible cultural significance be found, until the significance of the "find" has been determined by the appropriate authorities and local inhabitants, and until fitting treatment of the site has been determined and carried out.
- Buffer zones or other management arrangements should be established to avoid damage to cultural resources, such as sacred forests and graveyards. Local communities to which these areas belong should determine access procedures and should not be excluded from accessing these areas
- Contractor self-sufficiency in the collection, supply and storage of all fresh and potable water to be used in the construction camp and for the works 9this may require a desalination plant).
- A set of a set of protocols (a 'code of conduct') should also be established and agreed upon with the island elders to determine the social and cultural parameters for working on the island. These protocols should form part of the contractual obligations of the contractor. Measures to mitigate any

concerns should then be addressed in discussions with the island elders and through public consultation prior to any mobilization.

- All project employees, local and non-local, should be trained and inducted prior to the commencement of any work on core principles, including health and safety, gender and cultural awareness, the prevention of sexual abuse, exploitation, and harassment, child protection, core labor standards, and the agreed code of conduct. Education and training in STI, HIV/AIDS and COVID-19 awareness and prevention is an important health risk mitigation factor for both community members and projects workers.
- Site induction should also make construction personnel aware of the locations and importance of areas of cultural importance and significance, and it should be made clear that such areas are always to be avoided.
- The employment of a local community liaison officer (CLO) by the contractor will facilitate productive communication between the community and the contractor.
- Efforts to hire local people, including women and disadvantaged individuals, for unskilled and semi-skilled activities and labour; with at least minimum wage requirements to be met.
- For Ciguatera -
    - Risk assessment to determine if there is a need to test for dinoflagellates in fish tissues.
    - Removal of extracted materials from the reef surface quickly to reduce the likelihood of algae bloom.
    - Establishing a register to document any cases of Ciguatera brought to the attention of medical staff for a period of six months before, during, and six months after construction.
    - Reporting any cases to the appropriate authorities so that safeguards can be put in place (e.g., a notice to advise against consumption of herbivorous reef fish until further testing has occurred and/or sufficient time has passed).
- An EMMP that includes -
    - Relevant community protocols and a Community Liaison Plan. This should include regular meetings with the island elders and for the distribution of information (incudes notices) on the scope and schedule of construction, and on activities that could cause nuisance.
    - The ‘code of conduct’ to be agreed with local leaders and included in employment contracts. The contractor will need to ensure that workers actions outside the work site are controlled and that community rules are observed. This is likely to cover appropriate behavior around local men, women and children, restrictions on alcohol consumption, restrictions on fishing, the implementation of awareness programs, the implementation of the GRM and handling of complaints, the approach to hiring local labor, and implementation of a community Health and Safety Plan (HSP).
    - Security to be provided at the work site, such that there is a prohibition on unauthorized people (especially children) entering.
    - An active GRM, supported by the CLO. The community must be aware of the GRM and how to access it and the CLO.
    - A HSP (appropriate to the nature and scope of the works) to include details of -
        - Advisory and warning signage to be secured on fences, gates and sign boards, and provided in both the language of the islanders and the main nationality of the workers and repeated in English. With the works site to be fenced.
        - The location and response times to emergency hospital services (the provision of care is best met by having a qualified medical doctor in the construction team).
        - An emergency response plan (ERP) emergency medevac plan, with lines of responsibility for action.
        - Relevant and suitable protective personal equipment (PPE).
        - Strict controls on access to the works site, patrolled by trained security, preventing children and locals from accessing the site and dangerous machinery.

- Management procedures for the use of shared roads (including maintaining access to the coast).

6 Effective EIA of Coastal Engineering Projects

Key recommendations for effective EIA of coastal engineering projects are provided in this section. These recommendations are intended to guide government officers, project proponents and other key stakeholders on good EIA practices, as a basis for good planning decisions.

6.1 Terms of Reference

Terms of Reference (ToR) are the foundation for the EIA process and should allow for accurate scoping of the nature and extent of EIA investigations required. Strong, clear ToR should guide coastal development proponents and their consultants in undertaking EIA report writing, government officers responsible for assessing/consenting the development, and relevant stakeholders in their assessment of the final EIS or environmental reports.

ToR can be written by government EIA officers, or by the project proponent working with EIA officers. Tool 2 in the Regional EIA Guidelines (SPREP, 2016) provides a ToR template to assist EIA officers and proponents. This offers general guidance on the structure of an EIA report and what types of information that should be collected and reported on, as well as tips/advice to assist with EIA preparation and EIS review. The key potential impacts that may need to be assessed and managed for coastal developments are also identified.

The ToR template provided is designed to be modified and adapted for different types of development to support the preparation of quality EIA reports. A project ToR should be guided by the specific country's EIA legislation, regulations and policies, and the final ToR should be reviewed and agreed upon by both the EIA administrator and proponent, prior to moving through to the EIA stage of the development.

6.2 Scoping

Scoping is the process of identifying the issues to be addressed in EIA and the level of detail to which an issue is to be examined. Scoping is a fundamental early stage of the EIA process that enables the resources available to be focussed on the key issues, saving time and money. The key issues that should be considered with respect to coastal studies include:

- The predicted extent of the impact area, e.g., in relation to marine ecology (habitats and species).
- Identifying potentially significant impacts that require detailed assessment and insignificant impacts that do not (i.e., topics that can be 'scoped out').
- The adequacy of existing baseline data and scope for further studies, should they be deemed necessary.

Scoping Plume Modelling, Tuvalu

Due to the remoteness of Tuvalu's outer islands, mobilisation of large dredging plant is impractical. The approach proposed for dredging for a series of small boat harbours was, therefore, for an excavator working from the reef flat to use a rock hammer to break the platform and remove the loose material to a bucket and, from there, into trucks. In Nukulaelae, it was quickly discovered that the use of this approach was limited by the tidal depth across the reef platform and swell conditions, resulting in an effective operation time of around 3-4 hours per low tide cycle. Hence for Nui, where the works entail widening the existing channel (to minimise the works footprint) characterised by rapid water discharge, it was determined that the EIA investigations did not need to include plume modelling. Rather, a dredging plan is to be prepared and approved, and visual plume monitoring is to be undertaken (should any concerns be raised, the approach will be adapted).

- The approach to be taken to coastal process modelling studies, should any be required.
- The methods to be adopted for assessing the magnitude and significance of effects/impacts (including potentially cumulative and residual effects).

The focus of this stage should be on ‘scoping in’ those issues that could be potentially significant given the nature and extent of the development and ‘scoping out’ those that will not. For those issues scoped in, it is also important to closely define to what extent the subject needs to be examined (rather than simply examining all elements of it) and to design the survey and assessment work to be undertaken based on this. This should then be verified and agreed with the relevant stakeholders. Adopting this approach will result in better informed Regulators, better informed stakeholders, a more precise scoping opinion, a more efficient EIA process, and a more successful consent application. It also allows for early identification of possible mitigation and enhancement measures, allowing time for their development and better design.

The required scope of an EIA will be largely determined by the value, importance and sensitivity of the biological and social environment (the impact receptors) and the nature of the project (its characteristics, scale and area of influence). In general, coastal impact assessments should adopt a phased approach to baseline surveys characterising the environment, which can be set out and agreed in the scoping phase. It is essential that EIA investigations are proportionate and phased baseline investigations can inform this by first determining (often based on desktop review) if any features of interest, value etc. are present (detailed in Section 4). This should then inform the scope of further work required.

A central tenet of good scoping is that a formulaic approach is not simply applied. Effective scoping must be undertaken in relation to the specific context and requirements of the project in question, taking into account the considered views of all stakeholders. Suitably qualified and experienced persons should exercise judgement. This can save significant time and costs in data collection, report preparation and design/construction. For example, for some (but not all) consent applications for works in the marine environment, many landside issues (transport, air quality, noise etc.) can be scoped out or the scope of the investigation required reduced.

6.3 Stakeholder Engagement

Good stakeholder and public consultation is crucial for a successful EIA process and requires a considered and continuous approach. The approach taken to stakeholder engagement must consider the cultural norms and hierarchy of the location where the project is taking place.

The Pacific is characterised by extensive customary land ownership and direct linkages between community livelihoods, subsistence lifestyles, natural resource conditions and sustainable development. Within this context, an effective EIA process must be participatory, engaging the local community and customary land/resource owners likely to be affected by a development, as well as other relevant stakeholders, such as provincial or local government authorities, businesses, relevant non-governmental organisations (NGOs) (such as the Red Cross, environmental groups and civil society groups), and women’s, men’s, youth and church groups.

Stakeholder engagement should reflect a project’s level of risk and its anticipated impacts, and it should be designed to ensure communities have an opportunity to learn about, and participate in, decision-making processes and the activities that will affect them. Effective stakeholder engagement should meet four objectives, to:

- familiarise stakeholders with the project planning and approval process
- get input on potential perceived or actual project impacts
- get feedback on the project design and proposed impact mitigation measures
- build and maintain constructive relationships between all parties.

Typically, engagement with the local community, land/resource owners and other stakeholders is a requirement under EIA legislation. This is often supported by national guidelines that outline appropriate methods and timeframes for engagement and consultation, and that provide recommendations for ensuring adequate participation by, and representation of, affected communities.

6.4 Monitoring, Management, and Enforcement

The EIA process does not end once an approval is issued; it continues for the life of the project through environmental management, monitoring, reporting and enforcement, supported by a project specific EMMP. The EIA administrator must ensure that a project proponent prepares, implements, monitors and reports on the effectiveness of the EMMP. Further detail is provided in SPREP 2018 *EIA Guidelines for Coastal Tourism Development in PICT* (see Appendix 2, Section 10).

An EMMP should:

- describe all mitigation measures required to address the identified impacts of the project;
- identify responsibilities and timeframes;
- include performance objectives and targets; and,
- outline a monitoring and reporting schedule to assess the effectiveness of the mitigation measures.

The EIA administrator has an important role in overseeing the EMMP and coordinating independent monitoring (which may be able to be delivered by members of the local community) to ensure mitigation measures are being effectively implemented and development conditions are complied with. The EIA administrator will need to use enforcement provisions under relevant legislation if the proponent fails to apply mitigation measures, if mitigation measures are not working well, if environmental impacts occur, or if development conditions are breached.

What is an EMMP?

An Environmental Management and Monitoring Plan (EMMP) is a site or project specific plan developed to ensure that appropriate environmental management practices are identified and implemented during the various stages of a project, including pre-construction, construction, operation, decommissioning, closure and post-closure. It assigns responsibilities and timeframes. An EMMP is a working document that should be periodically reviewed and amended throughout the life of the project to reflect changing environmental conditions and developments in good environmental management.

Several government agencies may need to be involved in managing and monitoring a coastal development, which means it is important for the EIA administrator to establish clear guidelines regarding who is responsible for different areas of monitoring, when the monitoring should be undertaken, how compliance will be determined, how enforcement should be carried out, and ensure that contracts associated with the works capture these arrangements.

Ecosystem-based management, which is an integrated ‘ridge-to-reef’ or ‘whole of island’ approach for achieving environmental, social and economic goals, combines land use and development planning with environmental protection and production needs. An ecosystem-based management approach can be particularly useful for guiding coastal development in PICT because it recognises the physical and biological linkages between land and sea, encourages the use of scientific knowledge in combination with traditional and local knowledge, promotes coordination across all government and non-government agencies who manage different aspects of the coastal zone, and encourages the use of participatory approaches with local stakeholders to achieve increased climate resilience, healthier ecosystems, enhanced natural resource management and improved livelihoods.

It is recommended that a project’s EMMP includes a requirement for all environmental data gathered for the EIA to be provided to the Country’s EIA administrator. This data should then be stored and managed as an information asset. Ideally, data from coastal engineering EIA baseline and monitoring studies should be stored in a national database that allows for easy retrieval and analysis of information, and for the integration of data across project sites, where feasible, to support State of the Environment and MEA reporting, and the identification of cumulative impacts.

As a sister document to this guide, an EMMP Toolkit is being drafted that will include template, example EMMP's for coastal engineering projects.

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