Pacific Region Infrastructure Facility

Responsible Sourcing of Aggregates in the Pacific

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Abbreviations

AIFFP	Australian Infrastructure Financing Facility for the Pacific
BMP	Building material permit
COEP	Codes of Environmental Practice
DEPC	Department of Environmental Protection and Conservation
DoL	Department of Lands
ECD	Environment and Conservation Department
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
ESAT	Environmentally Safe Aggregates for Tarawa project
FAOLEX	Legislative and policy database compiled by Food and Agricultural Organization of the United Nations
FSM	Federated States of Micronesia
GDP	Gross domestic product
GIS	Geographic Information System
MELAD	Ministry of Environment, Land and Agricultural Development
MFMRD	Ministry of Fisheries & Marine Resource Development
MIMRA	Marshall Islands Marine Resources Authority
MRA	Mineral Resources Authority, PNG
MRD	Fiji Mineral Resources Department
NEPA	National Environmental Protection Act
NES	National Environment Service
NRC	Nauru Rehabilitation Corporation
OHS	occupational health and safety
PEA	Preliminary Environmental Assessment
PICs	Pacific Island Countries
PNG	Papua New Guinea
PREP	Pacific Resilience Programme
PUMA	Planning and Urban Management Agency
PWD	Public Works Department
QEMP	Quarry Environmental Management Plan
QMP	Quarry Management Plan
RMI	Republic of the Marshall Islands
SOPAC	South Pacific Applied Geoscience Commission (now part of SPC)
SPC	Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
TCAP	Tuvalu Coastal Adaptation Project
TISIP	Tuvalu Infrastructure Strategy and Investment Plan
TLTB	iTaukei Land Trust Board, Fiji
UN Comtrade	United Nations database that aggregates annual and monthly trade statistics
UXO	Unexploded ordnance

Executive Summary

The challenges of sourcing sustainable aggregates in the Pacific

The aim of this report on the responsible sourcing of aggregates in the Pacific is to support the identification of, and transition to, sustainable and resilient sources of quality, cost-effective aggregates for the infrastructure sector. The Asian Development Bank (ADB) has estimated that over $30 billion needs to be invested in Pacific Island Countries' (PICs) infrastructure by 2030. To achieve this will require very large quantities of building materials, including cement, aggregates, and concrete, much of which is not locally available. Sourcing affordable, quality aggregates of the right type has been a particular challenge in many PICs in recent years. This is of significant concern for infrastructure developers given that sand, gravel, and crushed rock are indispensable for concrete production, road base, road surfacing and land reclamation, the latter being of critical importance in a region that is highly vulnerable to the impacts of climate change. Mineral security is therefore a major issue in achieving development outcomes in the Pacific. The report identifies numerous challenges, including delays to infrastructure projects, high material and shipping costs, shipments that cannot be offloaded or loaded due to inadequate port facilities, lack of testing facilities to determine aggregate quality, and adverse impacts on infrastructure caused by poor quality or unavailable aggregate.

Perhaps the most concerning aspect of the aggregates sector in the Pacific Islands is the environmental and social impact of extraction. In numerous countries, the mining of sand and gravel from riverbeds, beaches, and reefs has intensified in recent years since these are often the easiest and cheapest options available to commercial operations and local people. In some cases, this has exposed rivers to increased flooding risk, as well as reducing the natural protection provided by beach systems to extreme weather events, resulting in chronic erosion, reduction in land area, and damage to housing and coastal infrastructure. Inappropriate aggregate extraction practices along coastlines and rivers also impacts local water quality and can disrupt coastal ecosystems. Even the terrestrial limestone quarries in countries such as Tonga are causing adverse environmental impacts and threatening groundwater supplies with documented cases of lead contamination 25 times World Health Organization standards in some locations. There is an urgent need to protect against these adverse impacts, particularly as infrastructure development and coastal protection measures place even greater demands on aggregate resources. The implementation of Principles for Responsible Sourcing of Aggregates in the Pacific proposed at the end of this report, along with the report's other recommendations, seek to address these environmental, social, and other challenges.

The report is divided into seven sections. After the introduction, section two describes the methodology used in this study. This includes a literature review of the major aggregate studies conducted over the past several decades, which are held in the library of the Pacific Community (SPC) in Suva, many of which until now have not be available in the public domain. The research team also undertook data analysis of aggregate trade in the region, consultations with 147 individuals in government, donor organizations, the community, with contractors and consultants, as well as field visits to Fiji, the RMI, Samoa, Solomon Islands, and Vanuatu. The 2023 Science Technology and Resources conference in Suva in November also provided the team with an opportunity to obtain initial feedback from regional stakeholders on the proposed Principles for Responsible Sourcing. Obtaining aggregate production data was particularly challenging during the study and even the main aggregate producing country in the region, Fiji, does not possess a central repository of all quarry production.

Next, Section 4 presents a market and supply chain analysis of the aggregates sector in the Pacific Islands region, assessing resource availability and regional trade, transportation and logistics, cost and quality considerations and potential alternative sources of aggregate. Section 5 examines the environmental, social, occupational health and safety (OHS), and economic dimensions of the aggregates sector by taking a region-wide perspective but zooming into country examples were relevant and where information exists. Section 6 presents a set of good practice principles for the responsible sourcing of aggregates in the Pacific, developed through consultation with regional stakeholders, insights from the study, and various regional and international good practice guidelines and safeguards. Finally, Section 7 presents conclusions, recommendations, and next steps.

Country profiles

Section three provides country profiles for each of the 14 countries in the region. This is the longest section of the report, and readers may wish to use it as a reference guide when looking for specific information about the aggregates sector in particular countries, rather than read it in its entirety in one sitting. For each country, a preliminary analysis of available aggregate resources and expected infrastructure demand is provided, followed by a summary of the country's geography and geology, discussion of aggregate extraction sites and known resources, and overview of the legal and policy framework, as well as the institutional and operating context.

Diverse regulatory, policy, and institutional landscapes

The profiles reveal significant diversity among countries in terms of their aggregate resources, policy, regulatory and institutional contexts, and capacity to effectively extract aggregates, even where these may exist in substantial quantities, as is the case in Nauru. Atoll countries such as Kiribati, Tuvalu, and the RMI face the greatest mineral security challenges and are especially vulnerable when it comes to aggregate supply, given their limited geological resources, isolation, fragile environments, and limited financial resources. These countries are highly reliant on imports of aggregates, including armor rock and coarse aggregates (crushed rock and gravel, etc.) for coastal protection and land reclamation. In this regard, supplies from Fiji have been especially crucial to meeting demand. Despite this dependence on external supplies, carefully designed lagoon aggregate dredging programs in these atoll countries, such as Environmentally Sustainable Aggregates for Tarawa (ESAT) in Kiribati and Tuvalu Coastal Adaptation Project (TCAP) in Tuvalu have demonstrated that at least some of these countries' fine aggregate demands can be met through sustainable extraction of lagoon sediments. Such programs can potentially be adopted in other atoll contexts such as in the RMI, parts of the Federated States of Micronesia (FSM) and elsewhere.

In some countries, legal and policy frameworks capable of regulating the aggregates sector do not exist, are poorly developed or, most commonly, are not enforced. The lack of enforcement is usually the result of a lack of resources and government capacity. For example, the Initial Environmental Examination for the ADB Outer Island Maritime Infrastructure Project in Tuvalu found that the Department of Environment had limited staff capacity to provide compliance monitoring, especially in the country's outer islands. Even in countries such as Fiji, with dedicated mining and environment ministries and well-developed legislation, enforcement of environmental regulations is inconsistent, particularly in the context of river gravel and sand extraction.

Aggregate self-sufficiency

The report provides a preliminary assessment of aggregate self-sufficiency, which is based on the expected demand associated with official infrastructure pipelines in each country, their existing aggregate extraction sites and known resources, and import/export data to indicate recent reliance on aggregate imports. A summary table for each country is provided at the start of each profile, which is then discussed in detail in the conclusion. However, it should be noted that the assessment is preliminary, and a comprehensive analysis of aggregate supply and demand was not possible during this study given the lack of detailed information about planned infrastructure projects, their specific aggregate needs, and aggregate production data for each country. Collecting this data would take considerably more time than allowed during the period of this project, as illustrated by the lack of response to requests for information from most governments in the region. Even when field trips were undertaken, most governments were unable to provide comprehensive production data.

As shown in the table below, the analysis reveals several broad patterns. First, as mentioned above, the atoll countries of Tuvalu, Kiribati, and the RMI have been particularly dependent on aggregate imports over the 3-year period 2020–2022, importing 12,136 tons, 8,038 tons, and 2,317 tons respectively for a combined total of 22,491 tons. The bulk of these imports were for coarse aggregates totaling 17,717 tons (~78%), with the remaining 4,774 tons (22%) being fine aggregates, i.e., sand. This reflects broader trends in PICs with most imports being coarse aggregates (~75%). With the exception of sustainably sourced lagoon sediments in the ESAT and TCAP programs, this dependence will continue into the future, driven in part by land reclamation needs and other climate change adaptation works.

Six countries, i.e., the FSM, Niue, Solomon Islands, Palau, Tonga, and Vanuatu, are assessed as having low to medium self-sufficiency in aggregates. As shown in the table below, key factors considered include the size of the planned infrastructure pipeline and hence expected aggregate demand, recent reliance on imports, and the lack of specific types of aggregate such as basalt or high-quality limestone, even where there are domestic aggregate resources, such as in Tonga.

Based on available information, the Cook Islands and Samoa were assessed as having medium self-sufficiency in aggregates. The Cook Islands are endowed with volcanic and limestone rock, as well as inland sand deposits, though the quality of these resources is variable. Relatively modest aggregate imports during the past 3 years suggest the country is relatively self-sufficient in meeting demand, though a substantial infrastructure pipeline of more than $488 million dollars may pose future challenges. In the case of Samoa, there are abundant quality basalt resources, with large quantities currently being used for the Apia Wharf development and other projects. There may even be some potential to export this basalt to nearby countries, though some stakeholders are of the opinion that Samoa's small size and potential environmental footprint of an aggregate export industry would lead to negative environmental and social impacts. Samoa has also imported around 546 tons of aggregate over the last 3 years, which suggests its quarry sector is currently not producing at its capacity.

Even where there are abundant resources, such as in Samoa, Nauru, and Fiji, the necessary infrastructure and capacity to extract these resources may be limited. First, countries may need substantial capital investment to maximize production, such as for investment in new equipment and access roads. Second, many countries do not have a workforce with sufficient skills to meet industry demand, as is the case in Nauru and Tonga, where there are shortages of blasting engineers. Other notable skill shortages identified are in planning for disasters due to natural hazards and risk management at quarry sites, good practice site maintenance, including environmental management and rehabilitation, occupational health and safety (OHS), and quarry management, particularly in areas such as knowledge of proper benching practice. Even Fiji, which has probably the most developed and best regulated quarry sector, companies and even the Mineral Resources Department may find it hard to fill positions.

Table 1: Preliminary Assessment of Aggregate Demand and Self-Sufficiency for Future Infrastructure Project Development

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
The Cook Islands	**High**	- Volcanic rock / gravel - Limestone rock (coronus)	**Medium**

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	~$488 million (NZ$687 million)[1] in projects identified in 2021 national infrastructure plan, with big ticket items requiring large volumes of aggregate for construction of civil buildings, runways, wharfs, sanitation, etc.	- Sand (inland quarries) - Coastal sand / gravel - Lagoon sand / gravel (potential but sensitive environment and currently no extraction)	2020–2022 imports: ~50.3 tons 2020–2022 exports: 0 Several of the islands are endowed with volcanic and limestone rock, as well as inland sand deposits (e.g., Aitutaki). However, quality is variable. Relatively small quantities of aggregate (~50.3 tons imported 2020–2022) indicating reasonable level of self-sufficiency.
The FSM	**High** Very large infrastructure pipeline in the order of more than $1 billion in the 10-year period leading up to 2025. It is not clear how much of this pipeline has been implemented. Projects identified by PRIF are also significant (~$118 million).	- Volcanic rock (basalt) (Chuuk and Pohnpei only) - Limited sand and gravel - Very small limestone deposits (Yap) - Lagoon / coastal sand (Pohnpei)	**Low-medium** 2020–2022 imports: ~2 tons 2020–2022 exports: 0 Yap – resource-poor in terms of high-grade aggregate. There are rivers but resource quantity appears to be low. Only small limestone deposits which are difficult to access. Chuuk – Hard rock (volcanic) reserves but currently only two quarries, one of which may not be operational. Past sand mining but current status unknown. Pohnpei – Currently three operational hard rock / volcanic scoria quarries. Historically environmentally harmful coral dredging from reefs. Potentially very substantial sand deposits in some locations. Kosrae – Currently two operational gravel / sand quarries with volcanic origin. UN trade data indicate only very small aggregate imports over the past 3 years but with a very large infrastructure pipeline and limited resources in some states, there is likely only a low to medium level of aggregate self-sufficiency.
Fiji	**Very high** As one of the largest economies in the Pacific, Fiji has a very large infrastructure project pipeline, in the order of $2.7 billion. PRIF	- Volcanic rock - Limestone - River gravel and sand - Coastal sand / gravel (no current extraction)	**Medium to High** 2020–2022 imports: ~388.9 tons 2020–2022 exports: 45,005 tons

[1] Values in New Zealand dollars converted using a 2021 yearly average exchange rate of NZ$1 = $0.71.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	has identified projects budgeted at $682.5 million.	- Lagoon sand / gravel (no current extraction)	Significant aggregate resources of all types (limestone, basalt/ volcanics, river sand and gravel) plus numerous operational quarries and river extraction sites. Fiji is an important exporter to the region and has reasonable self-sufficiency. The main challenge is sourcing these aggregates responsibly, particularly from Fiji's rivers. In addition, recent discussions with the MRD indicate that despite being an exporter, Fiji is currently facing challenges meeting domestic aggregates demand.
Kiribati	**High** Large infrastructure pipeline with approved projects from Kiribati's National Infrastructure Investment Plan (2022–2032) is valued at $562.37.	- Lagoon sand / gravel - Dolomite / limestone (Banaba island only)	**Low** 2020–2022 imports: ~8,042 tons 2020–2022 exports: 0 Successful sand extraction operations (ESAT) in Tarawa but, with the exception of the unrealized Banaba dolomite resource, no other types of aggregate, which makes it highly reliant on imports of hard rock, gravel etc. from countries like Fiji.
The RMI	**Low-medium** The Marshall Islands National Strategic Plan 2020–2030 does not provide detail on specific infrastructure projects; however, PRIF has identified four projects for potential funding at a cost of $52.86 million.	- Lagoon sand / gravel	**Low** 2020–2022 imports: ~2,317 tons 2020–2022 exports: 0 tons Highly dependent on import of hard rock aggregate, including armor rock for coastal protection and other works. However, based on available information, infrastructure pipeline appears to be relatively modest, with the Majuro airport terminal ($32 million) likely to need the most aggregate resources for runways, etc. Also, potentially good sand deposits at the northern rim of Majuro lagoon could meet some of this demand for this type of aggregate.
Nauru	**Low** "Priority" projects from Nauru's Integrated Infrastructure Strategic Plan 2019–2030 estimated to cost around $68.79 million.	- Dolomite / limestone	**Medium to High** 2020–2022 imports: ~12.5 tons 2020–2022 exports: 0 tons Nauru has a substantial dolomite reserve that should theoretically be able to fulfill all or most coarse aggregate needs over the coming years (and, if managed properly could be a source of exports). Minor quantities of sand imports (~12.5 tons) over past 3 years indicate it may require

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			continued imports of sand / gravel in coming years.
Niue	**Moderate** For the small size of the country, there is a substantial infrastructure plan valued at $173 million over 10 years (2023–2033).	- Limestone	**Low-medium** 2020–2022 imports: ~6.4 tons 2020–2022 exports: 0 tons Only two identified limestone quarries - small quantities of sand imports over the past 3 years indicate reasonable level of self-sufficiency. However, relatively large infrastructure pipeline may put pressure on existing quarries requiring increased imports of sand and other types of aggregate.
Palau	**Low to moderate** Top 20 prioritized projects in the National Infrastructure Investment Plan (2021–2030) are valued at $243 million and will require substantial quantities of aggregate for construction. PRIF has identified projects valued at $59.7 million.	- Limestone - Volcanic rock - Lagoon / coastal sand and gravel dredging	**Low to medium** 2020–2022 imports: ~114.3 tons 2020–2022 exports: 0 tons Five active quarries with volcanic and limestone rock and sand should be able to meet much of the aggregate demand, though past years have still required modest imports of sand, gravel, etc.
Papua New Guinea (PNG)	**Very high** Very large infrastructure pipeline in the order of $1.826 billion for potential PRIF projects alone. In addition, the "Connect PNG Plan 2020–2040" will require massive quantities of aggregate to build or rehabilitate 4,200 km of national roads and 16,200 km of provincial and district roads.	- Volcanic rock - Limestone - River gravel and sand	**TBC** 2020–2022 imports: ~1,450.4 tons 2020–2022 exports: 143 tons At least 23 quarries identified at time of writing plus potentially numerous other resources (and quarries) not identified. However, PNG's infrastructure pipeline, including road building is massive and will require extremely large quantities of aggregates for roads and other infrastructure. Also noteworthy is that PNG still imports aggregate (~1,450 tons between 2020–2022). Aggregate resources are potentially available but surveying and establishing a significant aggregates sector will require substantial resources and capacity building.
Samoa	**Medium-High (TBC)** A new national infrastructure plan has not been released following the 2011 5-to-10-year plan. The Apia Port upgrade project which has required significant volumes of aggregate is also scheduled for completion	- Hard rock (basalt) - Sand	**Medium** 2020–2022 imports: ~546 tons 2020–2022 exports: 0 tons Excellent basalt resources which appear to be largely sufficient to meet current

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	soon. However, a new Transport Infrastructure Plan has been developed and identifies several major projects which will require large volumes of aggregate.		demand, though ~546 tons of aggregate (mostly gravel /pebbles) imported in the last 3 years.
Solomon Islands	**High** The government's priority infrastructure pipeline of 2021 identified projects valued at $368 million. It is not yet known whether the projects identified will go ahead but PRIF has identified eight large projects with a total value of $264.5 million. As a result, it seems likely that aggregate demand will be substantial in the coming years.	- Limestone - River gravel / sand - Hard rock (volcanic)	**Low-medium** 2020–2022 imports: 26 tons 2020–2022 exports: 0 tons Almost all of the building materials permits issued are for river sand and gravel operations along the Lungga, Ngalibiu and Poha rivers, near Honiara with significant environmental and aggregate quality challenges. Hard rock resources (predominantly diorite) are available but will require substantial resources and capacity building to develop. Nevertheless, at least according to UN Comtrade data, Solomon Islands only imported around 26 tons of aggregate during the 3-year period 2020–2022.
Tonga	**Medium** The National Infrastructure Investment Plan identifies ~$232.75 million in priority projects to be implemented between 2021 and 2030. $197.1 million in projects have been identified by PRIF.	- Limestone - Beach sand (not sustainable)	**Low-medium** 2020–2022 imports: 124.6 tons 2020–2022 exports: 0 tons Tonga has limestone resources of varying quality to supply the infrastructure construction projects in the coming years. There will likely be a continued need to import better quality materials and sand to supply the infrastructure sector in the coming years, particularly sand, though only a modest 124 tons of aggregate was imported between 2020–2022. Nevertheless, the relatively large pipeline will likely increase aggregate demand beyond what Tonga can produce itself.
Tuvalu	**Medium** Compared to other countries in the region, Tuvalu has a modest infrastructure pipeline, with many of the projects identified under the 10-year Infrastructure Strategy and Investment Plan (2017–2026) likely to have already been completed, based on predicted timelines. PRIF has identified $70.6 million of future projects, with most requiring the importation of aggregates.	- Lagoon sand / gravel	**Low** 2020–2022 imports: 12,135.8 tons 2020–2022 exports: 0 tons Successful sand extraction operations for land reclamation (under TCAP) but there are no other types of aggregate locally available, which makes it highly reliant on imports of hard rock and gravel from countries like Fiji. Imports between 2020–2022 totaled more than 12,000 tons and, based on infrastructure development

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			plans and other future coastal adaptation works, these levels of aggregate import will likely continue over the coming years.
Vanuatu	**Medium to High** Current infrastructure development plan ends this year with new plan yet to be released. However, proposed projects will likely be as much, if not more, than the Vanuatu Infrastructure Strategic Investment Plan 2015–2024, which identified projects valued at $406 million. Projects identified by PRIF are valued at $171 million.	- Limestone (coronus material) - Basalt (mainly outer islands) - River gravel (outer islands) - Beach sand (not sustainable)	**Low-medium** 2020–2022 imports: 27.9 tons 2020–2022 exports: 0 tons Good limestone deposits on Efate but limited basalt with no operational quarry. Outer islands have sand, river gravel, limestone and small (but potentially bigger) quantities of basalt resources, though Vanuatu is still reliant on imports, with very large imports in recent years, though not all captured by trade data.

Source: Developed by authors using country specific infrastructure data provided by PRIF, the UN Comtrade Database (March 2024) and other sources. See start of country profiles for full list of sources.

Market and supply chain analysis

Fiji's importance as a regional supplier

Fiji is the most important source of aggregates for the Pacific Islands region. According to UN Comtrade data, between 2018–2022 it was effectively the only supplier of aggregates from within the region to other PICs and surpassed all foreign suppliers such as those from the People's Republic of China (PRC), Australia, and New Zealand. During this period, total exports from Fiji were 53,806 tons, comprising 46,502 tons of coarse aggregates (pebbles, gravel, crushed stone etc.) and 7,368 tons of sand. This represented 55% of all aggregates imported by countries in the region during the 5-year period and, if a very large, one-off shipment from Norway in 2018 is excluded from the data, Fiji was the source of 79% of all aggregate imports during the period.

Tuvalu and Kiribati were by far the largest buyers of Fiji's aggregates, importing 23,030 tons and 23,480 tons, respectively, and they were also the most consistent markets, importing aggregate in each of the 5 years during the period. The RMI was the third largest market, importing 1,395 tons. The large quantity of imports is explained by the limited geological resources in these countries and urgent infrastructure needs, particularly in relation to climate change adaption. In Tuvalu, the main use of aggregate has been to create new elevated land, while in Kiribati it is being used for a range of construction projects, as is also the case in the RMI. Other markets for Fiji's aggregates during the period were the Cook Islands, Nauru, Papua New Guinea (PNG), Samoa, Tonga, Vanuatu, and Wallis and Fortuna.

Three of Fiji's companies are responsible for the bulk of the country's exports with each owning hard rock and river gravel quarries. They include Flametree Development Ltd, Gold Rock Investment Ltd, and Standard Concrete Industries Ltd (a division of Basic Industries), all of which are based and operate on the main island of Viti Levu. Between them they operate 14 quarries, nine of which are currently operational. These companies all have crushing equipment and undertake beneficiation activities. Flametree is the largest exporter to other PICs though details about the quantity and value of its exports are not public. Flametree states that its Saru hard rock quarry in Lautoka, which began operating in 2010, is the only reliable source of road sealing chip in Fiji that complies with New Zealand Transport Agency, Fiji Public Works Department, and Fiji Road Authority specifications.

The role of suppliers from outside the region

Suppliers from countries outside of the region also play an important role in the Pacific Islands' aggregate supply. Other than Fiji, PICs sourced aggregates from the PRC (8% of all aggregates), the Philippines (4%), and Australia, New Zealand, and the United States (US) (1% of supply each). In addition, small quantities of aggregate were shipped from countries such as Malaysia, Singapore, and Türkiye and others, though in negligible quantities.

PRC suppliers have exported to many of the region's countries during the past 5 years, including Fiji, FSM, Kiribati, Nauru, Palau, PNG, Samoa, Solomon Islands, and Vanuatu. Most supplies have been destined for Fiji but the single biggest export during the period was 4,600 tons of coarse aggregates to FSM in 2018. Supplies of aggregate from the US have exclusively been to the RMI and most likely originate from one of the quarries in Guam.

PRC companies are well-known operators in the region and are major competitors for Australian, New Zealand, and Japanese contractors such as Downer, Reeves Envico, Hall Pacific, McConnell Dowell, Kitano, and others. They include major PRC state-owned/partially state-owned companies such as China Railway No. 5 Engineering Group, China Railway No. 14, China Harbour Engineering Company, and China Civil Engineering and Construction Corporation, which source aggregate for their projects locally but may also ship directly from the PRC or other countries outside of the Pacific Islands region. These companies have sometimes experienced difficulties in importing aggregate with one often reported story of a company trying to unload aggregates in the RMI for an infrastructure project but being rejected by local authorities due to quarantine concerns. There are no data on the quantities of aggregate that these particular companies ship to the Pacific Islands from outside the region, but it is likely they account for a significant proportion of the trade coming from the PRC each year.

Transportation and logistics

There are two main ways in which aggregates are shipped in the Pacific Islands region. The first is via chartered barges that carry bulk cargo with the key companies being Cruz Holdings and Gold Rock, both of which are Fiji-based. Hall Contracting also reportedly runs three barges out of Fiji, which have recently been servicing Tuvalu. The second is by scheduled ships that transport aggregates in containers. The main scheduled shipping companies include Neptune Pacific Direct Line, Matson, and Swire Shipping, each of which are based outside of the Pacific Islands region.

Shipping costs are high and can comprise around half of the cost of supplying aggregate from Fiji to other PICs. These high costs are due largely to the fact that ships typically only deliver one way and return empty because many countries have limited exports required by other countries in the region.

Lack of suitable, deep water port facilities, particularly in the atoll countries, means there are limits to the size of ships able to unload in some countries. Vessels are sometimes forced to moor offshore, which can present hazards in rough seas and stormy conditions. The last few years have seen several barges running aground, including two in Nukulaelae in Tuvalu, which were delivering materials for the Tuvalu Outer Island Maritime Transport Infrastructure Project, being funded by ADB. Barging can also be a problem if loading and landing facilities are difficult which, as discussed below, is a challenge Nauru needs to address if it is to increase aggregate exports to the rest of the region.

Aggregate costs

The cost of aggregates varies significantly depending on the country, type, quality, and amount of aggregate to be purchased, market conditions, and even the specific quarry it is from. In addition, transportation costs feature significantly in the final price buyers end up paying with remote locations far from the source incurring higher costs.

A desktop review of coastal protection in the Pacific Islands in 2017 determined the following costs to acquire “local materials” for protection works per cubic meter: aggregate/underlayer was $61, sand $38, and armor rock $115. These costs included supply and placement on site.

Transportation costs are a major part of aggregate costs used in infrastructure development in the Pacific, particularly in remote locations. Road transportation is usually not a major factor since distances between source and use within countries are typically between 50–100 km. One study reported that road costs range from between $0.38 to $0.77 per m^3/km. Shipping costs are considerably higher. The following examples illustrate typical costs:

- Scheduled container shipping from primary port**:** Aggregate is transported 3,000 km and then unloaded locally and transported to site. Typical freight costs would be $383 per m^3, including taxes and import duties.
- Remote location from primary port by barge**:** Aggregate is loaded at a primary port but is to be shipped 2,000 km to a remote location like Tuvalu, which requires chartering a barge. On arrival, the shipment is unloaded at a wharf, jetty, or directly onto land using a ramp. Based on typical barge rates, shipping costs would be $767 per m^3. To illustrate the costs involved, a recent aggregate shipment by barge from Fiji to a neighboring country was $230,100.

Quality considerations

A major challenge facing infrastructure developers in the Pacific is ensuring the timely and cost-effective supply of project-quality aggregate. Not all types of aggregate are suitable for every application. The three main types of aggregate material found in the Pacific Islands, i.e., coral aggregate derived from either live or dead coral and lagoon sediments (including sand); uplifted limestone (known as coronus material); and volcanic aggregate (e.g., igneous rocks like basalt) are typically used for different applications. Limestone, for example, one of the most common aggregates used in the Pacific Islands, is a versatile rock that, once crushed, is suitable for road base, concrete, and other applications. Aggregate made from volcanic rock such as basalt, which is typically much harder, is used to make structural concrete and pavement for high-volume roads, while coral aggregates are commonly used as base/sub-base for low volume and unsealed roads and, where no other materials exist, for concrete, though strength is typically lower than concretes made with limestone and volcanic rock.

There is considerable variation in the properties of these aggregate materials, even within the same type. For example, in the case of uplifted limestone, factors such as the type of the original coral from which the rock was formed, degree of recrystallization, amount of self-cementation and level of contamination by plastic fines, all determine strength and durability. These differences can even be found in limestone quarries from the same country and also same island, such as Tongatapu in Tonga.

Volcanic rock, sourced from hard rock quarries or rivers, is likewise characterized by different strengths and properties, with some contractors describing hard rock from some quarries in Fiji as being of poor quality, while others are described as “excellent rock”. This, coupled with river sand (and uncrushed gravel) that tends to be more rounded, rather than the preferred angular shape, explains why some quarries in countries like Fiji mix different rock types on site to produce aggregate with desired properties. There is also significant variation in the strength and suitability of marine sediments dredged from lagoons, with foraminiferal sediments being better suited to the strength requirements of certain concretes, such as those exposed to marine environments which require strengths as high as 50 megapascals.

The gold standard for ensuring aggregate meets quality specifications is to undertake testing in certified laboratories with trained staff. Discussions with donors and industry stakeholders in several countries revealed challenges with accessing labs or with labs that do not have the right equipment and staff with the necessary training on how to undertake testing. In Solomon Islands, the main problem is that the fluctuations in infrastructure activity, and hence aggregate demand, mean that labs do not have consistent income to ensure equipment is maintained; as a result, they may lose accreditation and skilled staff may leave. There is also a major challenge recruiting qualified operating staff for the laboratories and upgrading, accrediting, and operating labs is also very expensive. Even in Fiji, contractors have had difficulties in getting some aggregates tested.

Despite the generally lower quality and strength of coral aggregates, there are reports of successful outcomes for construction of roads, causeways, and even seawalls dating back to the Second World War. For instance, the US Army Corps of Engineers built roads and causeways in the RMI, which were impressive for their quality and resilience. One explanation for the quality of such infrastructure is the technique used. One donor representative explained that the US Army had "perfected the science of controlled drying of coronus material so that it sets like concrete". This has to do with the chemical reaction between water and the calcium carbonate. Such techniques are certainly worth exploring today, particularly in resource limited atoll countries and regions. However, the environmental cost of using coral materials on a large scale during the war years was often extreme and strict safeguards would need to be put in place if this approach is to be tried today.

A final point affecting the quality of materials available to projects is the influence of local rent-seekers in government or other organizations who, in some countries, have been known to push projects to source from quarries where they have a vested interest, but which have poor quality materials. Meanwhile, quarries with better quality materials are overlooked.

Potential alternative sources within the region

There are several potentially significant sources of aggregate within the Pacific Islands region that have not yet been fully utilized or explored yet could be with the right policies and support.

The first is Nauru, once renowned for its phosphate mining, which has large reserves of limestone dolomite, an anhydrous carbonate mineral that can be crushed to produce strong, high-quality aggregate suitable for concrete and other applications. This dolomite is a waste product resulting from decades of phosphate mining and its extraction would have the benefits of creating a valuable product and rehabilitating disturbed land, which is scattered with dolomite pinnacles. The Government of Nauru, through the Nauru Rehabilitation Corporation (NRC), is currently quarrying dolomite for armor rock and aggregate, primarily for its port redevelopment and to meet domestic construction demand, including 25,000 tons for the airport upgrade. However, Nauru plans to export both aggregate and armor rock to other Pacific atoll islands, such as Majuro in the RMI, Kiribati and Tuvalu.

Studies will first be required to fully assess the market potential and, assuming the findings are favorable, a suitably sized barge to transport the aggregate will need to be purchased to make deliveries economic and price competitive. Nevertheless, NRC has already delivered shipments using Vanuatu-based Ocean Logistics to both the RMI and Tuvalu at $45/ton (where 5,000 tons were purchased). Customers are obliged to arrange and pay for a barge to transport the aggregate. Increasing this export business is a key pillar of NRC's business strategy going forward.

Other challenges will need to be overcome if Nauru is to become a major exporter of aggregate such as ensuring port facilities are capable of loading aggregates to barges. There are reports such facilities being part of the current port redevelopment being built by China Harbour. Management of quarry operations is also allegedly not up to standard, which is apparently impeding production and roads, access points and benching are neglected, all of which would have to be addressed if Nauru is to maximize the potential of the dolomite resources. Quarrying is also affected by skills shortages, such as trained blasting engineers, a problem also reported in other countries such as Tonga.

The second source is a vast stockpile of ferro-nickel slag in New Caledonia, known as "Le Sland". The slag is a by-product of nickel processing that can be used as a supplementary material in cement and can also ground into a manufactured sand that can be used as an aggregate. The source is the nickel mining and processing operations of SLN, a subsidiary of French mining company Eramet. There are currently 25 million tons of Le Sland stockpiled in New Caledonia and around 1 million tons are added each year. Le Sland has been used in New Caledonia for land reclamation, road base, concrete blocks, tetrapods and Seabee units for coastal protection, and other purposes for over 20 years. Despite this, uptake in the Pacific Islands is slow. Several contractors stated that they had been looking into the use of Le Sland in various projects but that the idea had been abandoned, though the reasons were not clear. Further testing and engagement with Pacific users and standards bodies in the Pacific will be needed to build confidence in Le Sland so that its full range of properties and suitability for infrastructure applications is better understood.

A longer-term option for countries might be to produce ore-sand by-products from silicate-rich metal ores for both domestic and export markets. Ore sand is a relatively new innovation that adds new processing circuits to create an additional product to the primary mineral being mined. Ore sand has numerous applications, including as construction aggregate and other industries (e.g., silica sand). Global mining giant Vale has already begun commercially producing and selling ore sand at some of its operations in Brazil and there is potential for existing mining operations in Fiji, PNG, and Solomon Islands to do the same, provided the economic and technical analysis is favorable. One newly operating gold mine in Fiji has already expressed interest in exploring the production of ore sands, while discussions are being held with other companies in Fiji and beyond.

Several other PICs have the potential to be net exporters of aggregate. As the third-largest island country in the world with diverse geology, PNG has significant potential to export all aggregate types to neighboring countries, such as nearby Palau and Solomon Islands. PNG may also be the best place for river extraction given the sheer number and size of its rivers and their ability to naturally recharge. To date, however, the quarry sector has been focused on supplying materials for the domestic mining and oil and gas industries and construction sector, with only very small quantities of aggregate exported during the 2018–2022 period. If PNG is to become a net exporter to the region, significant industry engagement will be needed to understand the barriers and market drivers for aggregate production and export, as well as information on the location, type, and quality of aggregates available.

As with Nauru, there is potential to quarry limestone / dolomite on Banaba Island, a raised limestone island in the Gilbert Islands of Kiribati, some 300 km east of Nauru but many challenges lie in the way. Similar to Nauru, Banaba (also known as Ocean Island) was the site of extensive phosphate mining during the 20th century, which has left the landscape littered with dolomite pinnacles. It also resulted in the displacement of most of the island's population who were resettled in the north of Fiji on Rabi Island after World War II. Although a small population remains, commencement of dolomite mining will have to be approached carefully given recent opposition by some of the displaced population to plans by Australian company, Centrex, to resume phosphate mining on the island. Nevertheless, consultations with officials in Kiribati indicate that there is interest among some Banabans to develop an aggregate industry on the island. In addition to careful consultation, other practical barriers would also have to be overcome if a dolomite industry is to be developed. One includes the lack of suitable landing and shipping facilities. Another includes the lack of heavy equipment on island necessary for breaking up the limestone and transporting and loading aggregates on ships. Roads will also have to be cleared to enable access to mined areas where there is limestone.

Environmental, social, occupational health and safety, and economic aspects

Environmental and social impacts and management

The report also examines the environmental and social aspects of the three main types of aggregate extraction undertaken in PICs: river gravel and sand extraction, quarrying, and lagoon dredging and sand mining.

Extraction activities impact river systems by altering the physical and chemical environment and consequently impacting the biological and anthropogenic surrounding environment. The observed effects are widespread and cumulative, resulting in decreased biodiversity and harm to the livelihoods of surrounding communities through loss of fishing grounds, flooding, and scarcity of clean water. The impacts of river extraction are documented through case studies of Fiji and Solomon Islands, where such activities are common and are known to have adverse impacts.

The atoll countries have been especially impacted by unsustainable sand mining for several decades though the commencement of projects such as ESAT in Kiribati and TCAP in Tuvalu appear to be delivering sustainable solutions to the significant aggregate challenges in these counties. They also serve as a model for other atoll countries and regions to understand lagoon aggregate extraction in a sustainable manner. Sand and coral mining are a problem in certain states of FSM, such as Yap, as well as in the RMI and Palau. Even in Tonga, where beach sand mining has been banned, unregulated extraction continues and has degraded beaches and impacted coastal housing and infrastructure. The way in which some of Tonga's estimated 10 limestone quarries are operated also poses a threat to groundwater and, in many quarries, the quality of aggregate is substandard.

Land access remains the most challenging issue in hard (and soft) rock quarry operations in some PICs. For example, the land at Quoin Hill, on Efate Island, Vanuatu has been reported to have a good quality basaltic outcrop suitable for construction material. However, the land falls under customary land tenure and the project has been opposed by local villagers and the people of Nguna Island, one of the offshore islands in the north of Efate for several years. There has been an ongoing court case trying to determine the rightful owners.

The quarry sector is an important contributor to local, regional, and national economic development, particularly in developing countries, benefitting not only the people who work in quarries but also surrounding businesses and the government. Beneficial effects include creating local employment, generating revenue from taxes and royalties, and creating economic multipliers, such as the development of new businesses resulting from increased demand for goods and services. The quarry sector may also have indirect positive effects on the broader local economic structure through public and private investment in roads, power networks and other infrastructure.

The quarry sector also supports the building and construction industries by providing critical materials, such as aggregates, sand, concrete, and dimension stones required for the construction of houses, public buildings, roads, airports, and energy projects, among others. The quarry sector also plays a critical role in climate change adaptation and response in the Pacific Islands since it provides the materials essential for constructing seawalls, reclaiming land, and building climate-resilient infrastructure.

Despite this, and with the exception of Fiji, the economic and social impacts of the aggregates sector are also poorly understood, including OHS systems and performance at the quarry level, employment contribution of the sector, its contribution to gross domestic product, and royalties collected. In large part this is due to poor monitoring, reporting, and public disclosure of performance data. Based on what little data is available, the report examines the situation in a variety of PICs.

Good practice principles for responsible resource extraction

The report presents a set of principles for the responsible sourcing of aggregate in PICs. The principles respond to concerns among donors, Pacific Islands governments, communities, and others that the sourcing of aggregate for infrastructure projects in the Pacific Islands often comes at a significant environmental, social, and economic cost, as described in the report.

The principles draw on examples of international good practice and regionally specific guidelines, as well as insights from key stakeholders, to provide guidance on the responsible sourcing of aggregates for the infrastructure sector. They include general principles applicable to all types of aggregate operations, encompassing both environmental and socio-economic issues. Next are principles specific to each of the main types of aggregate operations in the Pacific Islands, namely: river gravel and sand operations; beach sand mining, lagoon dredging and coral reef mining; and hard rock quarries. Finally, principles have also been developed for governments seeking to improve responsible aggregate sourcing.

The principles are written primarily for infrastructure donors and contractors, extraction companies, and government agencies with a role in implementing, regulating, or funding aggregate extraction activities. However, they are also for all stakeholders who may be impacted or have an interest in aggregate extraction operations in PICs.

Recommendations

The report provides a range of recommendations for improving the supply of responsibly sourced aggregates in the Pacific. The recommendations are divided into seven categories as follows: 1) improving sustainable extraction practices through adoption of a set of principles for responsible sourcing of aggregates in the Pacific; 2) building on lessons learned to improve sustainable aggregate supply in resource-poor atoll countries; 3) improving knowledge of aggregate resources in the region; 4) better management of information and data; 5) enhancing capacity to monitor and enforce compliance with regulation and good extraction practices; 6) addressing other challenges reported by infrastructure developers; and 7) utilizing alternative aggregate sources in the region.

1. Improving sustainable extraction practices through adoption of principles for responsible sourcing of aggregates in the Pacific

- **Refine and further develop the responsible sourcing principles:** The responsible sourcing principles developed in this study provide a basic framework for aggregates. They differ from various donor safeguards in that they are adapted for the region and sector. Suggested actions include conducting regional workshops to obtain input from key stakeholders and developing accompanying implementation guidance.
- **Support transitions from river gravel and sand extraction to hard rock quarrying in countries such as Fiji and Solomon Islands**: This was a recommendation of the 2018 Baseline Assessment of Development Minerals in Fiji; similar measures will likely be needed in Solomon Islands to support a transition to quarrying.

2. Build on lessons learned to improve sustainable aggregate supply in resource-poor atoll countries

- **Evaluate the potential benefits and feasibility of establishing projects like ESAT and TCAP in other PICs, such as the RMI:** Both ESAT and TCAP are delivering positive outcomes in terms of providing a supply of sustainably sourced material for land reclamation and construction purposes. In the RMI, the need for both fine and coarse aggregates for coastal protection around Ebeye is particularly critical because of its small size, high population density, and exposure of critical infrastructure to wave action with little option of retreating due to constrained land availability. It should be cautioned, however, that lagoon sand and gravel resources are not a replacement for armor rock/riprap and other hard rock materials necessary for coastal protection, which many atoll countries and regions do not have. One alternative solution is to increase the supply of prefabricated concrete products, such as Seabee unit pods from Fiji, where manufacturing of these products is well established.
- **Provide alternative livelihood options and skills development to ensure bans on illegal beach sand mining and lagoon extraction do not harm local people:** Efforts to enforce bans on beach sand mining or illegal lagoon dredging must be accompanied by measures to provide employment and economic opportunities for those whose livelihoods may be displaced. Without such support, efforts to end illegal mining will likely be ineffective and, at worst, harm those who depend on extraction for their livelihoods.

3. Improving aggregate resource knowledge in the region

- **Provide support for surveys in countries where there is limited knowledge of aggregate resources:** The study found that information about the region's aggregate resources and potential is patchy and limited to relatively few areas, despite the various resource assessments conducted in the past by organizations such as the South Pacific Applied Geoscience Commission (now SPC). If the region is to improve the availability of aggregate resources for infrastructure development, contractors, donors, and governments need more comprehensive knowledge of the local materials available.

4. Better management of information and data

- **Countries should establish centralized databases of quarries and other extraction sites, including developing a comprehensive Geographic Information System database:** Even where data on aggregate extraction operations exist, they may not be collated in one place within government or available to infrastructure developers or other users. For instance, Fiji, which has the most developed quarry and river gravel extraction sectors in the region, does not have a centralized database of all aggregate operations in the country. Vanuatu and PNG face similar problems. Centralized access to this information is particularly important in PNG, which will have massive aggregate demands to build and repair thousands of kilometers of roads alone in the coming years.
- **Relevant government agencies should compile and publicly report on the economic and social impacts of aggregate extraction:** The study found that reporting on such things as OHS performance, employment, gross domestic product contribution and royalties generated by the sector is absent in most countries and, even where it is reported, is not up to date. For instance, seven of the countries in the region do not report any data on employment in the quarry and mining sector. Relevant government agencies must have visibility of this performance since it is essential to policy development and improving performance, whether this is safety performance or increasing economic returns. It is also desirable that environmental performance data are compiled and, ideally, publicly reported.

5. Knowledge transfer and capacity building

- **Conduct training in good quarry management practice and related skills:** Skill areas could include:
    - Proper benching practice to ensure safe and efficient extraction of rock
    - Explosives handling and use
    - Natural disaster planning and risk management at quarry sites
    - Good practice site maintenance, including environmental management and rehabilitation.
    - Good practice OHS

  The knowledge transfer could take the form of workshops, short courses, or other training programs delivered in-country or at universities such as Fiji National University and the University of the South Pacific.
- **Provide relevant government agencies with the resources and skills to monitor and enforce compliance with environmental regulations:** Poor or non-existent environmental monitoring and enforcement is a major problem in PICs, even in countries such as Fiji. It is essential that government agencies with responsibility for monitoring are provided with the financial and human resources to undertake this monitoring on a regular basis. Environmental impact assessment training by organizations such as the Secretariat of the Pacific Regional Environment Programme's Environmental Monitoring and Guidance Division, which produced successful outcomes in Niue, could be delivered in other countries in the region, prioritizing those facing heightened challenges in maintaining environmental compliance. Donors could consider supporting such programs and perhaps funding a dedicated position in one of the relevant government ministries.
- **Each country should develop and make publicly available a Quarry Management Guide:** Like the Quarry Management Guide produced by Vanuatu's Public Works Department, the guide would outline the key requirements for establishing, operating, and closing a quarry so operators and regulators know what is expected and can follow or enforce permit conditions.

6. Addressing other challenges reported by infrastructure developers

A range of other challenges to sourcing aggregate of the right quality for infrastructure development were reported by developers and other key stakeholders.

- **Provide necessary facilities and expertise to test aggregates for quality:** This should be done especially in countries and areas undergoing large infrastructure investments. Support may be needed to establish, or maintain accredited laboratories, calibrate equipment, and recruit or train staff with requisite skills.
- **Ensure good practice community engagement to avoid landowner disputes over land access, royalties, and other issues in potential quarry operations:** Experience in the large-scale mining sector demonstrates that positive early engagement with landowners, including indigenous peoples, is essential when seeking to develop extractive operations.

7. Utilizing alternative aggregate sources in the region

- The study also finds that there are several promising alternative sources of aggregate in the region which have not been utilized, or fully utilized, that have significant potential to meet at least some of the demand from infrastructure development. Nauru's dolomite resources stand out as a highly significant source of quality aggregate, which is suitable for many applications, from concrete to road surfacing. This may also be the case with the dolomite resources on Kiribati's Banaba Island. In the case of Banaba, surveys suggest that there may be as much as 2 million tons of limestone aggregate which would not only go much of the way to making Kiribati self-sufficient, but also enable it to become a dolomite exporter to other countries in the region.

Another potential source of aggregate is the Le Sland in New Caledonia, which is currently not being used, despite the best efforts of French company SLN to all but give it away. Finally, PNG likely has enormous aggregate resources, though only a fraction of this appears to be used, with much remaining to be surveyed. Longer term, there is also the possibility of manufacturing ore sand in some of the region's existing and upcoming metallic mines, such as in Fiji and Solomon Islands.

1. Introduction

One of the biggest challenges facing infrastructure developers in Pacific Island countries (PICs) is sourcing cost-effective, quality, and timely supplies of aggregates suitable for infrastructure needs. Aggregates like sand, gravel, and crushed stone are an indispensable input into the manufacture of concrete, road bases, and road surfaces, as well as for land reclamation, which is of great importance in a region that is highly vulnerable to the impacts of climate change. Coastal protection measures, including the construction of sea walls, are also dependent on supplies of armor rock, which some PICs simply do not have and must import at significant expense.

Mineral security is therefore a major issue in achieving development outcomes in the Pacific.[2] Mineral security exists when all people have sufficient and affordable access to the minerals necessary for human development, including for shelter, mobility, communication, energy, and sustenance.[3] To date, few studies have explored the relationships between mineral supply and resilience. The project team identified numerous examples of delays to critical infrastructure projects, increasing material

[2] Rogers, P. et al. (2023). *Building Disaster and Climate Resilience through Development Minerals*. United Nations Development Programme (UNDP), Pacific Community (SPC) and The University of Queensland (UQ), Suva, Fiji.

[3] Franks, D.M., Keenan, J., and Hailu, D. (2022). Mineral Security Essential to Achieving the Sustainable Development Goals. *Nature Sustainability* 6(1): 21–27.

costs, shipments that cannot be offloaded due to inadequate port facilities, and adverse impacts on infrastructure caused by poor quality or unavailable aggregate. While many of these issues have been documented for the first time in this report, the issues described have been understood by governments and donors alike for some time.

A few examples illustrate the challenges that exist. In Vanuatu, civil works on the Bauerfield Airfield runway were delayed by 5 months in 2017 because of concerns regarding biosecurity risks when the contractor shipped aggregates from an unapproved source.[4] In 2016, in Kiribati, the Bonriki Airport's newly upgraded runway, apron, and taxiway were deteriorating mere months after project completion due to the use of poor quality mudstone aggregate in the asphalt surfacing. And in Tuvalu in 2019, the lack of suitable deep water port facilities forced vessels containing aggregate to moor offshore, resulting in two barges running aground on the reef in Nukulaelae during hazardous seas. Most recently, a contractor in Tuvalu reported difficulties obtaining 4–6 ton boulders for coastal protection works stating that "no one wants to ship this type of rock". This has led the contractor to consider importing prefabricated concrete tripods.

But of all the PICs, it is the atoll countries that face the greatest mineral security challenges in the sourcing of aggregates due to their limited geological resources, isolation, fragile environments, and limited financial resources. As the Marshall Islands Secretary of the Ministry of Works, Infrastructure and Utilities stated recently, "The limited supply of aggregates is one of the biggest challenges facing the Marshall Islands construction sector. Any construction requires a lot of aggregates and the supply issue needs to be addressed."[5] It is for this reason that efforts are now underway to identity sustainable sources of lagoon aggregates in the Marshall Islands (RMI) under the Pacific Community (SPC)-led Pacific Resilience Programme (PREP II), in a similar approach to the Environmentally Sustainable Aggregates for Tarawa (ESAT) project in Kiribati.

The final and perhaps most concerning aspect of the aggregates sector in the PICs is the environmental and social impact of extraction. In numerous countries, the mining of sand and gravel from riverbeds, beaches, and reefs has intensified in recent years, since these are often the easiest and cheapest options available to commercial operations and local people. In some cases, this has exposed rivers to increased flooding risk, as well as reducing the natural protection provided by beach systems to extreme weather events, resulting in chronic erosion, reduction in land area, and damage to housing and coastal infrastructure. Inappropriate aggregate extraction practices along coastlines and rivers also impacts local water quality and can disrupt coastal ecosystems. There is an urgent need to protect against these adverse impacts, particularly as infrastructure development and coastal protection measures place even greater demands on aggregate resources.

It within this context that the Pacific Regional Infrastructure Facility (PRIF) has commissioned this study on Responsible Sourcing of Aggregates in the Pacific. The study's overall aim is to support the identification of, and transition to, sustainable and resilient sources of quality, cost effective aggregates for the infrastructure sector. The study has six specific objectives: 1) developing a knowledge base of the aggregates sector in the Pacific Islands region represented by the 14 PRIF member countries; 2) reviewing the experience of aggregates sourcing by infrastructure developers in these countries; 3) identifying fundamental issues, including challenges, associated with sourcing aggregates by infrastructure developers; 4) identifying, documenting, and assessing alternative materials and their potential to be used in infrastructure projects; 5) assessing options to improve the quality and adequacy of supply of aggregates; and 6) developing recommendations and good practice principles for the responsible sourcing of aggregate in the Pacific.

The report is divided into seven sections. Section 2 describes the approach and methods used in the study. Section 3 provides a knowledge base of the aggregates sector in the region with country

[4] The World Bank (2020). *Implementation Completion and Results Report: Vanuatu Aviation Investment Project* (P154149).

[5] SPC, 13 July 2023. 'Geophysical Survey of the Majuro and Ebeye Lagoons completed'. https://www.spc.int/updates/news/2023/07/geophysical-survey-of-the-majuro-and-ebeye-lagoons-completed.

profiles for each of the 14 PRIF member countries containing summaries of their geological characteristics, aggregate resources and extraction, aggregates required for future infrastructure development, and overviews of relevant laws, regulations and institutions governing extraction. The comprehensiveness of the data on aggregate resources in this section differs markedly depending on the country, which is determined by numerous factors including availability of the data and willingness and ability of relevant government representatives to share it; without country visits and in person meetings, it can be very challenging to obtain data.

Next, Section 4 presents a market and supply chain analysis of the aggregates sector in the Pacific Islands region, assessing resource availability and regional trade, transportation and logistics, cost and quality considerations and potential alternative sources of aggregate. Section 5 examines the environmental, social, occupational health and safety (OHS), and economic dimensions of the aggregates sector by taking a region-wide perspective but zooming into country examples were relevant and where information exists. Section 6 presents a set of good practice principles for the responsible sourcing of aggregates in the Pacific, developed through consultation with regional stakeholders, insights from the study, and various regional and international good practice guidelines and safeguards. Finally, Section 7 presents conclusions, recommendations, and next steps.

2. Approach and Methods

The study was undertaken in three phases between mid-July and the end of December 2023. Phase 1 entailed developing a knowledge base of aggregate resources in each of the 14 PRIF member countries. This knowledge base is presented in the report in the form of country profiles, with each profile containing: a summary of the geography and geology of the countries; summary of aggregate extraction and known resources; analysis of the aggregates required for national infrastructure development; overview of the legal and policy framework, focusing on those laws, regulations and policies that have direct relevance for aggregate extraction and sourcing; and a description of the institutional and operating context, focusing on the government institutions involved in regulation of the aggregates/minerals sector and the environment. The geological analysis is, in parts, quite technical, though readers can choose to engage with these sections to the extent that they are comfortable and still get a picture of the aggregate resources available in each country.

Phase 2 assessed the experience of infrastructure developers in sourcing aggregates in the region, documenting key issues and challenges faced and exploring options to improve the quality and adequacy of aggregates supply. This Phase relied heavily on consultations with key stakeholders, which are described in more detail below. Finally, Phase 3 involved assessing alternative sources of aggregate supply within the region, as well as developing a set of good practice principles to support the responsible sourcing of aggregates in the Pacific in the future.

A range of research methods were used in the study, commencing with a literature review of the major aggregate studies conducted over the past several decades, which are held in the library of the SPC in Suva, many of which until now have not be available in the public domain. This literature was augmented by reports and other studies held in the personal library of one of the consultants for this study, which have been accumulated over a career spanning more than 4 decades working on aggregates in the region, including with the South Pacific Applied Geoscience Commission (SOPAC), Fiji's Mineral Resources Department (MRD) and finally with SPC. Additional literature and data were sourced from government and donor websites (ADB, PRIF, World Bank, SPREP), as well databases such as the FAOLEX which contains information on all of the legislation and policies relevant to the regulation of aggregates in the region. The United Nations Comtrade database was also used to support analysis of the trade in aggregates in the region, which is presented in section 5.

Where data or other information were found providing clear global positioning system coordinates, existing aggregate extraction sites were mapped using either ARC GIS Pro or Google Earth Pro. In some cases, where little information was available on a country's quarries and other extractive operations, it was possible to use Google satellite imagery to visually identify quarry or river extraction sites by looking for certain landscape features (e.g., open pits) and the presence of rock-crushing equipment.

Stakeholder consultations were conducted with a total of over 151 people from more than 77 organizations encompassing community members at a small number of sites in Solomon Islands, government agencies, major infrastructure contractors and donors, hard rock, river extraction and lagoon dredging operators, and international agencies such as SPC (Appendix B). These consultations were undertaken remotely via video conferencing apps (Zoom and Teams), email and phone conversations, and during field trips to Fiji, Samoa, Solomon Islands, Republic of the Marshall Islands (RMI), and Vanuatu.

A full list of stakeholders engaged during the study is provided in Appendix B. Formal data collection requests were also sent to PIC governments using a data request template, though the rate of response was poor and was only successful in countries visited during field visits.

To develop the good practice principles for responsible sourcing of aggregates, a roundtable was organized at the Science Technology and Resources Conference in Suva in November 2023. Participants at the roundtable included relevant government representatives from Fiji, Kiribati, New Caledonia, Solomon Islands, and Tuvalu. Also attending were researchers from Australia, New Zealand, the United States (US), Fiji, and the United Kingdom (UK). Using stakeholder input from the roundtable, along with insights from the study and international good practice guidance and safeguard policies, a set of good practice principles for responsible sourcing of aggregates was developed.

Figure 1: Map of the Pacific Islands Region

Source: PRIF https://www.theprif.org/where-we-work

3. Country Profiles

3.1 The Cook Islands

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
The Cook Islands	**High** $488 million (NZ$687 million) in projects identified in 2021 national infrastructure plan, with big ticket items requiring large volumes of aggregate for construction of civil buildings, runways, wharfs, sanitation etc.	- Volcanic rock / gravel - Limestone rock (coronus) - Sand (inland quarries) - Coastal sand / gravel - Lagoon sand / gravel (potential but sensitive environment and currently no extraction)	**Medium** 2020–2022 imports: ~50.3 tons 2020–2022 exports: 0 Several of the islands are well endowed with volcanic and limestone rock, as well as inland sand deposits (e.g., Aitutaki). However, quality is variable. Relatively small quantities of aggregate (~50.3 tons imported 2020–2022) indicating reasonable level of self-sufficiency.

3.1.1 Geography and geology

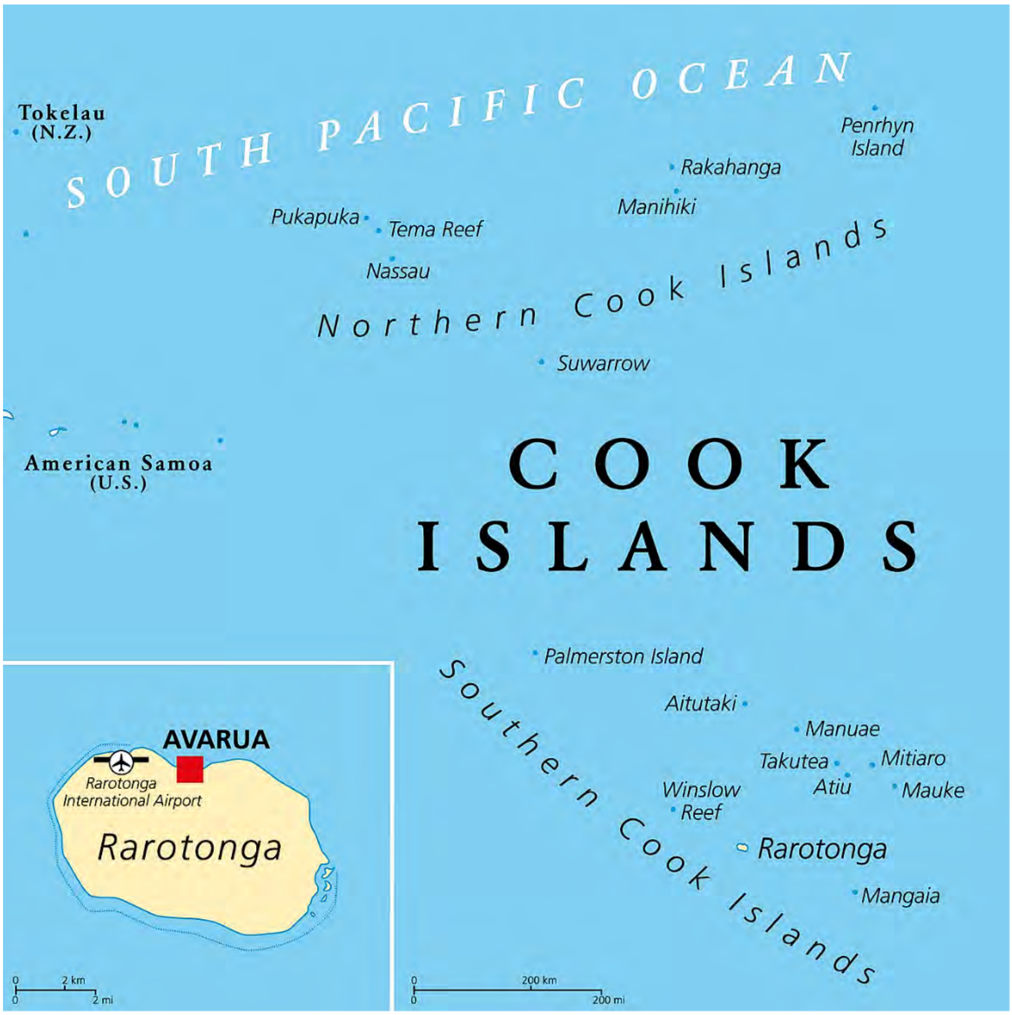
The Cook Islands are located in the South Pacific Ocean, approximately 3,500 km northeast of New Zealand. Despite their small land area (240 km^2), the Cook Islands cover 1.8 million km^2 of ocean. The country comprises 15 islands and atolls, which are divided into the Southern Cook Islands and the Northern Cook Islands. The geography of the islands varies, with low-lying coral atolls and towering volcanic islands with mountainous interiors. The northern group consists mostly of atolls, while the southern group consists of both volcanic islands like Rarotonga and low-lying coral atolls.

The southern group comprises the islands of Atiu, Mauke, Mitiaro and Mangaia. These are classified as "makatea" islands, which are formed as uplifted rims of limestone (of coral origin) wholly or partly surrounding volcanic islands.[6] There are also the islands of Aitutaki and Rarotonga which are volcanic islands surrounded by coral reefs. A summary of the islands' geology is given below (Table 2).[7]

[6] Wood, B. L. (1967). Geology of the Cook Islands. *New Zealand Journal of Geology and Geophysics*. 10(6).

[7] Maoate, P. (2009). Cook Islands Technical Report: Geological Assessment of Selected Aggregate Sources on the Islands of Aitutaki, Mangaia and Atiu, Southern Cook Islands (pp. 8–9). Ministry of Works, Rarotonga, Cook Islands; Gillespie, R.G. and Clague, D. eds. (2009). *Encyclopedia of Islands* (No. 2). Univ of California Press.

Figure 2: The Cook Islands



Source: World Atlas https://www.worldatlas.com/maps/cook-islands

Table 2: Summary of the Geology of the Main Southern Islands Group in the Cook Islands

Island	Geology
Rarotonga	High volcanic island surrounded by a fringing reef from the Holocene era. It formed around 2.3 million years ago, when the seafloor buckled in the area nearby. The crustal loading from the formation of Rarotonga uplifted Mauke, Mitario, Atiu, Manuae, and Takuet Islands, rising them above the sea and exposing the fringing reefs, which eventually became the rocky coastal areas known as “makatea”. Rarotonga’s exposed coral reefs became fossilized limestone creating the rugged coastlines and plateaus. The interior is comprised of incised volcanic peaks.
Aitutaki	Low, volcanic island sitting on a “near-atoll” setting. The reef comprises 15 islands, 13 of which are coral sand. Aitutaki, Rapota, and Moturakau are volcanic. In Aitutaki, there are two main types of igneous rocks, nepheline basalts and basaltic pyroclastics. The latter include palagonitic lapilli tuff and agglomerate, basaltic scoria, breccia, and cinder. The tuff and agglomerate are well bedded and contain abundant fragments of coral limestone. Around Aitutaki, coral debris and sand make up a coastal strip of varying width and continuity. Beach deposits such as coral sand, partly cemented conglomerate and lithified beach-rock form two levels 1 m and 2–2.7 m above high-tide level around Aitutaki.
Mangaia	The volcanic rocks of Mangaia are deeply weathered. Fresh outcrops tend to be restricted to streams and to a lesser extent on road cuttings. The volcanic core is mainly basalt, commonly ankaramite. A few outcrops of fine-grained basalt occur

	on the southern and western slopes of the central hills, while a coarsely porphyritic basalt outcrop protrudes in the Vau Roa valley. The limestone forming the makatea is dense, fine-grained, and seems to be cemented coral sand. In contrast to the dolomitic limestone of the north islands, the limestone is a remarkably pure calcareous limestone with virtually no magnesium carbonate. Coral sand forms a coastal belt 90–180 m wide, consisting of a few inches of mixed humus and coral sand and debris overlying uncemented yellowish coral sand.
Atiu	Atiu consists of a central elevated, flat-topped mass of volcanic rock surrounded by the makatea. The volcanic rocks are deeply weathered, mostly to red clay containing limonitic nodules and black manganiferous veins. In the head waters of the Tikoi and Te Kapi streams, the fresh rock can be seen in situ and consists of tuffs and basaltic breccia resembling breccias found in Rarotonga. At the head of the Te Kapi stream, the breccias are traversed by basalt dykes. The makatea averages about 1,100 m in width and on the seaward side ends in a small cliff up to 6 m high[8]. The outer 46 m of the makatea consist of calcite and aragonite of both primary and secondary origin, and the inner parts more than 370 m from the shore consist of irregularly dolomitized limestone.

Source: Tawake and Maoate 2009; Gillespie et al. 2009

3.1.2 Summary of aggregate extraction sites and known resources

Onshore aggregate extraction

There are two main sources of aggregates in the Cook Islands: hard rock from quarries and coral aggregates from coastlines and lagoon flats. According to the Toitu Te Whenua (Land Information New Zealand) website, there are two existing hard rock quarries in Rarotonga, which may be under the same permit given their proximity to each other (Figure 3).[9] Based on the island's geology and volcanic history, the quarries are potentially a good source of basalt and scoria.

Research conducted by SOPAC on Aitutaki and Mangaia Island suggested there are sources of high-quality basalt and limestone that could supply the demand for aggregates for construction on these islands.[10] Vaitiare on Aitutaki Island is a small-scale quarry with a resource estimation of 1,200m^3 of in-situ fresh basalt rock, as reported approximately 15 years ago. However, the study also suggested a new resource site adjacent to the Vaitiare quarry, which, based on the presence of a crusher from the most recent satellite imagery (Google Earth Pro), suggests it may be currently active. Another site was suggested in Mangaia as a moderate-quality resource of basalt that could meet the short-to-medium-term needs for aggregate on the island.

[8] Wood, B.L. (1967). Geology of the Cook Islands. *New Zealand Journal of Geology and Geophysics.* 10(6).

[9] Toitu Te Whenua (Land Information New Zealand), Cook Islands Quarry Polygons. https://data.linz.govt.nz/layer/52260-cook-islands-quarry-polygons-topo-125k-zone4/

[10] Tawake, A. K. & Maoate, P. (2009). Cook Islands Technical Report: Geological Assessment of Selected Aggregate Sources on the Islands of Aitutaki, Mangaia and Atiu, Southern Cook Islands.

Figure 3: Location of Quarry Sites Located Near the Landfill/Waste Management Facility in Avarua, Rarotonga

Source: Google Earth Pro Imagery

Being an island with massive and uplifted limestone rock, Mangaia Island also has abundant limestone resources. This limestone is comprised of more than 93% $CaCO_3$, making it a good long-term source to meet sand and gravel demand on the island. The sites investigated during the 2009 SOPAC study are listed below (Table 3).

Table 3: Summary of the Quality of the Aggregate Resources on the Islands of Aitutaki, Mangaia. and Atiu, Southern Cook Islands

Island of Origin	Site	Aggregate Type	Quality
Aitutaki	Vaitiare Site 2	Crushed basalt gravel	Good quality aggregate, limited quantity
	Mania	Crushed scoria basalt gravel	Moderate quality aggregate
Mangaia	Karanga	Crushed limestone gravel	Low strength
	Karanga Sand	Crushed limestone sand	Moderate strength and durability
	Kaauo	Crushed limestone gravel	Moderate strength and durability
	Keia	Crushed basalt gravel	High strength and durability, selective extraction required to avoid contamination
A u	Atiu Quarry	Crushed limestone gravel	High strength and durability

(Source: Tawake and Maoate 2009)

On Aitutaki Island, sand for construction is sourced mostly from inland deposits since sand mining along the coastline and within 30 m inland from the high-water mark is prohibited under the Environment Act. However, the impacts of illegal activities were still evident during the 2009 SOPAC study. It was also noticed that many inland sand extraction pits were abandoned and not rehabilitated. Unlike Aitutaki, Mangaia Island has limited sand resources along the coastline and most of the sand extraction occurs in limestone pockets inland near to the coast.

Offshore aggregate extraction

Sand dredged from Aitutaki Lagoon is also another potential source of sand. However, tourism is a major source of income for the islands and establishing a dredging operation needs to be considered carefully and research conducted to identify suitable sites where dredging will not have adverse effects on the lagoon environment and coral reef diversity.

3.1.3 Aggregates required for national infrastructure development

The Cook Islands released its 10-year (2021–2031) National Infrastructure Investment Plan (NIIP) in 2021 as part of the strategy to achieve the country's National Vision and the National Sustainability Development Plan. The NIIP targets all sectors of infrastructure such as transport (road, airports, ports, water), information and communications technology, education, waste and sanitation, and coastal protection, among others.[11] The projects outlined in the plan are grouped into "Programs" and are estimated to cost ~$488 million/ NZ$687 million.[12] Many of the most costly projects will require significant quantities of aggregates for concrete and other structures, such as the sewerage and sanitation program in Rarotonga ($39 million/NZ$55 million), construction of health infrastructure under the National Health Infrastructure Program ($54.1 million/NZ$76.2 million), and Rarotonga Airport upgrade ($47.6 million/NZ$67.1 million).

PRIF members have identified various projects (as shown in Table 4 below) that may be supported in the coming years. Some of these projects align with or are part of projects identified in the Cook Islands NIIP. The table summarizes each project, its predicted budget and provides an initial assessment of potential aggregate demand.

Table 4: Infrastructure Projects Identified by PRIF Members for the Cook Islands and Predicted Aggregate Demand

Sector	Project Name	Budget ($ million)	Potential Aggregate Demand	Assumptions
Water and sanitation	Wastewater and Sanitation Project	20	Moderate	Requires moderate volumes of aggregates for concrete, and sand for water treatment. Likely to involve the construction of reservoirs, pumping stations, treatment plants, and pipelines among others.
Energy	Renewable energy development project	TBD	Depending on the project scope	Requires varying amounts of aggregates. Proper estimates are to be determined with a clear project scope, e.g., solar energy projects would require concrete for solar panel platform footings
Energy	Renewable energy projects identified in the Cook Islands	Up to 20	Depending on the project scope	As above

[11] Cook Islands National Infrastructure Investment Plan 2021–2031. www.ciic.gov.ck/wp-content/uploads/2021/08/CI-Full-NIIP-2021-FINAL.pdf. Accessed 7/12/2023.

[12] Values in NZ dollars converted using a 2001 yearly average exchange rate of NZ$1 = $0.71.

Sector	Project Name	Budget ($ million)	Potential Aggregate Demand	Assumptions
	National Infrastructure Investment Plan			
Energy	Scoping and design of new energy programme including replacement in Northern Group mini-grids	TBD	Low	None to low quantity of aggregates required (e.g., where there is a need for repairs, say repair of service roads, and concrete footings among others)
Total ($)		**40**		

TBD = to be determined.

Source: PRIF, 2023; relevant project reports where available

3.1.4 Overview of the legal and policy framework

According to the Constitution of 1965, the Cook Islands are a self-governing state; however, the country remains part of the Realm of New Zealand with Her Majesty the Queen as the Head of State. The High Commissioner is the Queen's representative who is appointed and acts on the advice of the Cabinet, the Premier, and the appropriate Ministers.[13]

Land and resource ownership

The Constitution does not address natural resources or the environment, however, it does deal with issues regarding landownership, customary laws, and practices. Part I, Article 8 of the Constitution establishes a system of 15 representatives from all islands, called the House of Ariki (Maori Chief's Council), that discusses matters affecting customs and traditions such as land and resource use of intertidal and marine reef areas, especially those of cultural and historical importance, and makes recommendations to the Legislative Assembly.

In the Cook Islands, the land falls under five categories: Crown Land, Customary Land, European Land, Native Land, and Native Freehold land.[14] Unlike other PICs, only a small proportion of land is under customary ownership. Only three out of 15 islands have customary land: Mangaia, Mitiro, and Pukapuka. Native freehold land in all 12 islands can be partitioned and exchanged but cannot be transferred except to the Crown for public purposes in exchange of payment and/or compensation, and it cannot be devised, only inherited in accordance with customs. It also cannot be sold or mortgaged except to the Bank of Cook Islands. Landowners can lease and grant easements to another citizen, but restrictions apply. There are no restrictions for the Crown.

The legal framework governing landownership and transactions is provided for under several pieces of legislation, including: the Cook Islands Act 1915, the Land Use Act 1969, the Lease (Facilitation of Dealings) Act 1970, the Leases Restriction Act 1976, and Lease Restriction (Amendment) Regulations 2006.

[13] Secretariat of the Pacific Regional Environment Programme (SPREP) and EDO NSW (2018). *Review of Natural Resource and Environment Related Legislation, Cook Islands*. https://brb.sprep.org/content/review-natural-resource-and-environment-related-legislation-cook-islands. Accessed 06/12/2023.

[14] ADB (2020). *Land Acquisition and Compensation Completion Report: Cook Islands: Improving Internet Connectivity for the South Pacific Project*. June. https://www.adb.org/sites/default/files/project-documents/50110/50110-001-sddr-en.pdf. Accessed 20/12/2023. See also Paterson, D. (n.d.). *Overview of Land Systems in English-speaking Island Countries in the South Pacific*. http://www.paclii.org/law-and-culture/An%20overview%20of%20Land%20Systems%20in%20English%20speaking%20Island%20countries%20of%20the %20South%20Pacific_Power%20Point.pdf. Accessed 22/12/2023.

The Cook Islands National Seabed Minerals Policy of 2014 states that the people of the Cook Islands are collectively the resource owners of all marine resources within the country's exclusive economic zone (EEZ) and that these resources "are managed by Government for the benefit of our people, now and for generations to come".[15] This policy is aimed at high-value seabed minerals such as manganese, which can be extracted from nodules within the EEZ but all metallic and non-metallic minerals are owned under the same principle.

Relevant legislation

The Cook Islands Act 1915 (Amended 2016)

The Cook Islands Act 1915 (Amendment No. 4 of 1982) recognizes customary practices including customary land, land titles, and succession of land.[16] Much of this Act provides for matters affecting land ownership and administration.[17] Under Part X (Section 362) of the act, the High Commissioner can purchase any land for public purposes or acquire by grant, lease, or easement any land, for and in the name of Her Majesty. Part XI establishes the Land Court and regulates access to native land. Part XII contains provisions relative to customary land and the definition of customary title in land. Other parts of the act deal with partition and exchange of native land, alienation of native land, native succession and other legal issues affecting natives.

Environment Act 2003

The Environment Act applies throughout the Cook Islands, except the Outer Islands unless otherwise specified by the Higher Commissioner by Order. The act was established to provide the baseline for protection, conservation and sustainable management of the environment and all natural resources.[18]

The Environment Act is the main legislation dealing with extraction of aggregates in the Cook Islands. Section 70 (2) deals with "regulating or prohibiting the taking of gravel, sand, soil, rock, coral or like materials", which are regulated through the Environment (Permits and Consents) Regulations 2011.

The act establishes two institutional agencies including the National Environment Service (NES) and the Island Environment Authorities, comprising an Environment Authority in each of the islands. The NES, headed by the Director of Service, is the main government agency that administers the act. The Island Environment Authorities assist the NES in identifying environmental issues and priorities, preparing guidelines, making recommendations to the appropriate minister, and determining applications for development permits. In addition, the act places limitations on specific activities such as building, developments, and sand removals in particular foreshore and wetland areas.[19]

[15] Cook Islands National Seabed Policy.
https://dsm.gsd.spc.int/sopac/dsm/dsm_laws/Cook_Islands_Seabed_Minerals_Policy.pdf. Accessed 24/12/2023.

[16] Food and Agriculture Organization of the United Nations. Cook Islands Act 1915 (Amendment No. 4 1982). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC065478/. Accessed 18/09/2023.

[17] Food and Agriculture Organization of the United Nations. Cook Islands Act 1915 (Amended 2016). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC065474/. Accessed 22/12/2023.

[18] Food and Agriculture Organization of the United Nations. Environment Act 2003. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC048637/. Accessed 22/12/2023.

[19] Secretariat of the Pacific Regional Environment Programme (SPREP) and EDO NSW 2018, Review of Natural Resource and Environment Related Legislation, Cook Islands. https://brb.sprep.org/content/review-natural-resource-and-environment-related-legislation-cook-islands. Accessed 06/12/2023.

The Outer Islands Local Government Act 1988

The Outer Islands Local Government Act provides for the establishment of the Islands Council, which carries out the following functions:[20]

1. To assist the government in the governance of the islands;
2. To administer the provisions of ordinances and by-laws;
3. To make, revoke or alter by-laws;
4. To assist in the coordination of any activity relevant to the economic and social development of the island;
5. To advise on or determine any matter, issue or dispute referred to it by any person or organization.

Marine Resources Act 2005

The Marine Resources Act does not cover non-living marine resources such as sand and gravel.[21] It only makes provision for the management, conservation, and sustainable use of fisheries resources of the Cook Islands and regulates matters such as fisheries resources conservation and development; authorization of fishing activities; monitoring, control, and surveillance; and legal proceedings.

Seabed Minerals Act No.5 of 2019 (Amends the 2015 Act)

The Seabed Minerals Act establishes a framework for regulating activities related to the extraction of the seabed minerals including prospecting, exploration, recovery of minerals, and retention of areas of minerals that have known commercial value but where recovery is not currently economically viable.[22] The Cook Islands Seabed Minerals Authority is responsible for the administration of this act and for granting relevant permits. The act also establishes the Seabed Minerals Advisory Committee to be act as an official avenue for the Authority to obtain community perspectives about the development of seabed minerals.[23]

Under this act, seabed minerals include mineral resources of any part of the seabed including but not limited to "mineral resources in crust, sediment, nodule, hydrothermal deposit form which contain metalliferous or non-metalliferous elements."

Policies

Seabed Minerals (Exploration) Regulations 2020

The Seabed Minerals (Exploration) Regulation outlines the rules regarding the application for and grant of exploration licenses by the Seabed Minerals Authority. It also outlines obligations relating

[20] Outer Islands Local Government Act 1988. https://cook-islands.tradeportal.org/media//Outer%20Islands%20%20Local%20Government%20Act%201987.pdf Accessed 22/12/2023

[21] Food and Agriculture Organization of the United Nations. Marine Resources Act 2005. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC098954/. Accessed 22/12/2023.

[22] Food and Agriculture Organization of the United Nations. Seabed Minerals Act No.5 of 2019. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC201780. Accessed 22/12/2023.

[23] Cook Islands Seabed Minerals Authority, Advisory Committee. https://www.sbma.gov.ck/advisory-committee. Accessed 22/12/2024.

to the conduct of exploration under license, as well as monitoring and enforcement guidelines.[24] Schedule 3 determines the purpose and content of the Environmental Management Plan (EMP), which establishes a plan of work for baseline studies and environmental assessment, along with management of adverse environmental impacts of exploration activities on the marine environment.

Seabed Minerals (Royalties) Regulations 2013

Under this regulation, all holders of a mining license must pay a royalty to the Revenue Management Division of the Ministry of Finance and Economic Management.[25] A fee of 3% of the export value of the minerals is required under the Seabed Minerals Act 2019. This applies to the export of polymetallic minerals and not quarrying, dredging, or seabed mining.

Environment (Permits and Consents) Regulations 2011

This is the main regulation dealing with the Environmental Impact Assessment process and the roles and responsibilities of appropriate government agencies.[26] According to the Environment Act (Part 5), any person who proposes a development project must submit an application permit to the NES, including an environmental impact assessment (EIA), detailing the environmental impacts of the project and the proposed actions to mitigate these impacts. NES then publishes the details of the project for public consultation (includes communities or any other government department or agency affected by the project). After reviewing the EIA and the public's recommendations, NES makes a decision to issue a permit (with or without conditions), request more information, or decline the application. Within 14 days of receiving the notice of refusal, the applicant may appeal to the decision to the Minister.

3.1.5 The institutional and operating context

National Environmental Service

The NES is the agency responsible for:

1. enforcing the Environment Act 2003 and associated regulations to manage environmental matters in the Cook Islands;
2. managing projects relating to biodiversity and conservation of natural resources; and
3. monitoring and evaluating activities with significant environmental impacts and reviewing EIAs.

[24] Food and Agriculture Organization of the United Nations. Seabed Minerals (Exploration Regulations) 2020. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC214308. Accessed 22/12/2023.

[25] Food and Agriculture Organization of the United Nations. Seabed Minerals Act No. 6 2019. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC201780. Accessed 26/12/2023.

[26] Secretariat of the Pacific Regional Environment Programme (SPREP) and ECO NSW 2018, Review of Natural Resource and Environmental Related Legislation, Cook Islands. https://library.sprep.org/sites/default/files/sprep-legislative-review-cookislands.pdf. Accessed 22/12/2023.

The NES issues three main types of applications and permits based on the type of activity and its environmental impacts (Table 5).[27] All dredging work, mining, and quarrying activities are subject to the EIA permit process and require a management plan.[28]

On Rarotonga, there are no regulations dealing with the exploitation of sand on private land. The activity is simply an arrangement between the contractor and landowner to mine sand.[29] Sand mining directly from beaches ended in 1997 with some limited exceptions. Sand mining is not, in fact, zoned in Rarotonga, other than that it is not allowed landward within 30 m of the mean high water mark.

Quarrying of volcanic rock for aggregate is regulated by the NES and requires an Environmental Permit. Quarrying activities must go through the EIA process and be approved by the NES. A management plan is also required as per the Environmental Act 2002.

Seabed Minerals Authority

The Seabed Minerals Authority is the key regulator of seabed minerals in the Cook Islands. It administers the Seabed Minerals Act 2019 on behalf of the government.

Ministry of Infrastructure

The Ministry of infrastructure is responsible for delivering and managing major infrastructure project across the Cook Islands including bridge and structure improvements, roads, drainage systems, coastal protection infrastructure, water and sanitation infrastructure, airports, and wharfs.[30]

Table 5: Summary of the Three Main Types of Applications and Permits Required to Conduct Different Types of Activities, Including Dredging, Mining, and Quarrying

Permit type	Description
Environmental Approval	A permit required for the construction of a standard residential dwelling or non-construction purposes such as land clearance. Once the Environmental Approval is issued by National Environment Service, the applicant must also obtain a Sanitation Permit from Te Marae Ora Ministry of Health and a building permit from Infrastructure Cook Islands before they proceed with the construction.
Environmental Consent	The Environmental Consent is to protect the Cook Islands from any significant environment impact. It applies to high-risk areas that are important to the Cook Islands heritage, biodiversity, and landscape. Activities required to obtain Environmental Consent are: specific land clearance (foreshore, sloping land, wetlands and streams); earthworks – relating to excavation, drainage, roads and building platforms; tourism and commercial extension; and renovation that leads to removal of coral.

[27] National Environment Services (2022). Applications and Permits. https://environment.gov.ck/applications-permits/. Accessed 19/09/2023.

[28] Leslie, D. (n.d.). Land Zone Definitions for Rarotonga. Prepared for the Government of Cook Islands and the Land Resources Division, Secretariat of the Pacific Communities. https://library.sprep.org/sites/default/files/72_3.pdf. Accessed 06/12/2023.

[29] Ibid.

[30] The Ministry of Infrastructure Cook Islands. https://ici.gov.ck/. Accessed 19/09/2023.

Permit type	Description
Environment Impact Assessment	An Environment Impact Assessment (EIA) permit is granted to an applicant that is conducting an activity, project, or development that is likely to cause significant environment impact. Activities that require an EIA permit include all dredging work, mining, and quarrying.

Source: National Environmental Service Cook Islands Website, Applications and Permits. https://environment.gov.ck/applications-permits/. Accessed 22/12/2023.

3.2 Federated States of Micronesia

Initial assessment of aggregate self-sufficiency

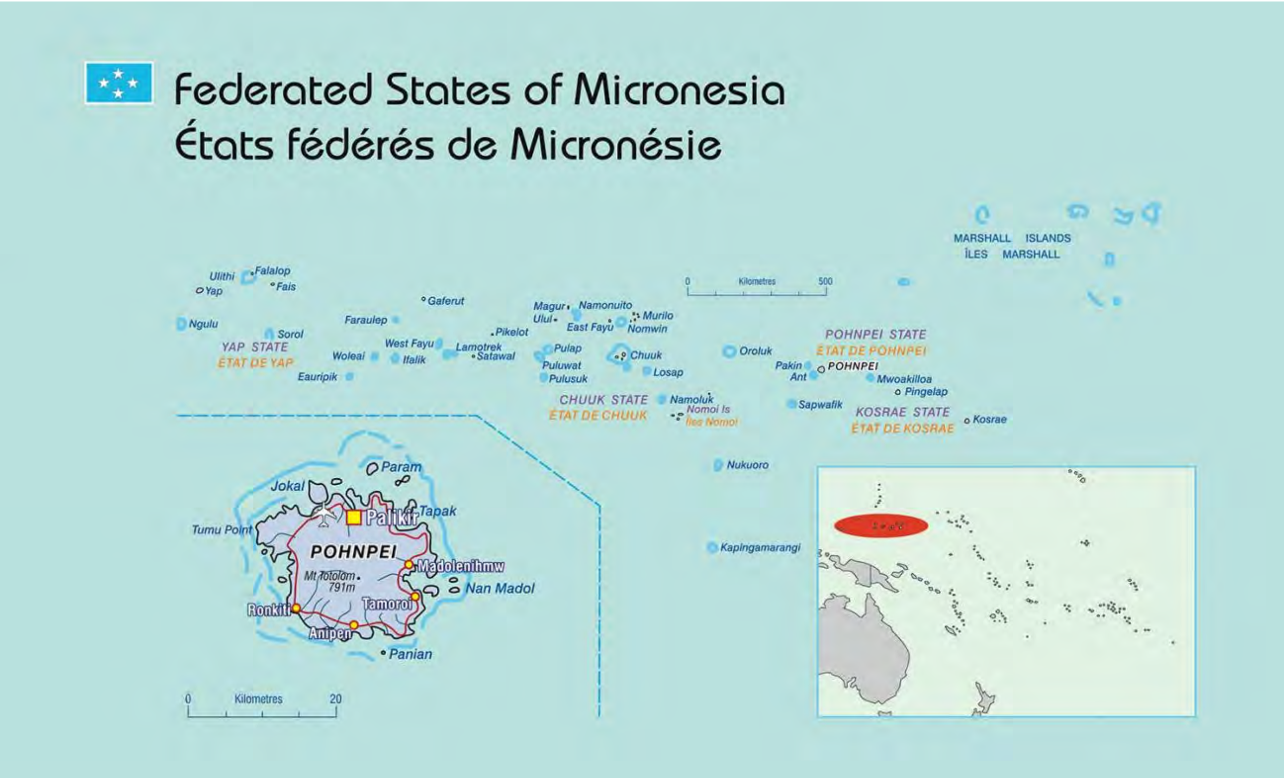
Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
FSM	**High** Very large infrastructure pipeline of more than $1 billion in the 10-year period leading up to 2025. It is not clear how much of this pipeline has been implemented.	- Volcanic rock (basalt) (Chuuk and Pohnpei only) - Limited sand and gravel - Very small limestone deposits (Yap) - Lagoon / coastal sand (Pohnpei)	**Low-medium** 2020–2022 imports: ~2 tons 2020–2022 exports: 0 Yap - resource poor in terms of high-grade aggregate. There are rivers but resource quantity appears to be low. Only small limestone deposits which are difficult to access. Chuuk – Hard rock (volcanic) reserves but currently only 2 quarries, one of which may not be operational. Past sand mining but current status unknown. Pohnpei – Currently 3 operational hard rock / volcanic scoria quarries. Historically environmentally harmful coral dredging from reefs. Potentially very substantial sand deposits in some locations. Kosrae – Currently 2 operational gravel / sand quarries with volcanic origin. UN trade data indicate only very small aggregate imports over the past 3 years but with a very large infrastructure pipeline and limited resources in some states, there is likely only a low to medium level of aggregate self-sufficiency.

3.2.1 Geography and geology

The Federated States of Micronesia (FSM) is a group of 607 mountainous islands and low-lying coral atolls in the western Pacific lying between longitudes 137°E and 165°E and latitudes 5°N to 10°N. It shares borders with Palau to its west, the Northern Mariana Islands to the north, RMI to the west, and Papua New Guinea (PNG) to the south (Figure 4). FSM comprises four states: Yap in the west, Chuuk and Pohnpei in the central part of the country, and Kosrae in the east. Pohnpei state is host to the federal government based in Kolonia and the country's capital, Palikir. The four states of FSM make up part of the larger island group known as the Caroline Islands, which also includes the Republic of Palau.

FSM has a total land area of around 700 km^2, with an EEZ covering around 2,996,430 km^2. In 2023, the country had an estimated population of around 106,194,[31] with around 6,900 people living in the capital, Palikir. Chuuk is the most populous state in the country with around 50,000 people and is also home to Weno Island, the state capital and largest city.

Figure 4: Map Showing the Location of the Four States of the Federated States of Micronesia



Source: SPC website

Geology, stratigraphy, and sediments of FSM

In the FSM west, the islands comprising Yap form an island arc system on the eastern convergent margin of the Philippine Sea Plate and are connected to the Palau island arc in the southeast, and the Izu-Mariana arc system in the north. The Yap island arc is situated on the margin of the Caroline Plate which is subducting under the Philippine Sea plate. The other three states of the FSM (Chuuk, Pohnpei, and Kosrae) lie on the Pacific Plate, east of the Mariana-Yap-Palau trench system along the Caroline ridge (Figure 5).[32]

The origin of the islands and the volcanic activity that produced them remains somewhat controversial. It has been proposed that the Caroline Islands originate from a hot-spot and the

[31] Pacific Community. https://www.spc.int/our-members/federated-states-of-micronesia/details. Accessed 22/12/2023.

[32] Rehman, H.U., Hideo, N. and Kawai, K. (2013). Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia, Western Pacific. *South Pacific Studies*, 33(2).

resulting magma ejections.[33] However, a number of chemical anomalies have caused some experts to have doubts about the about the Caroline Islands “hot-spot only origin”, such as the presence of “silica-undersaturated and -oversaturated lavas on the same islands” (p111).[34] The hot spot theory can be traced back to 1963, when it was proposed that with seafloor spreading, fixed sources of lava in single locations in the earth’s mantle would rise to build volcanoes.[35] As the seafloor moved over the fixed source of lava coming from the mantle, a line of volcanoes would result. These lines of volcanoes have come to be called hot spot tracks. As the volcano moved away from the hot spot the volcano would become extinct and subside. The Emperor-Hawaii chain is a classic example of this process and the bend in the chain illustrates a change in the Pacific Plate direction of motion, while the fixed plume continues to produce volcanoes.[36]

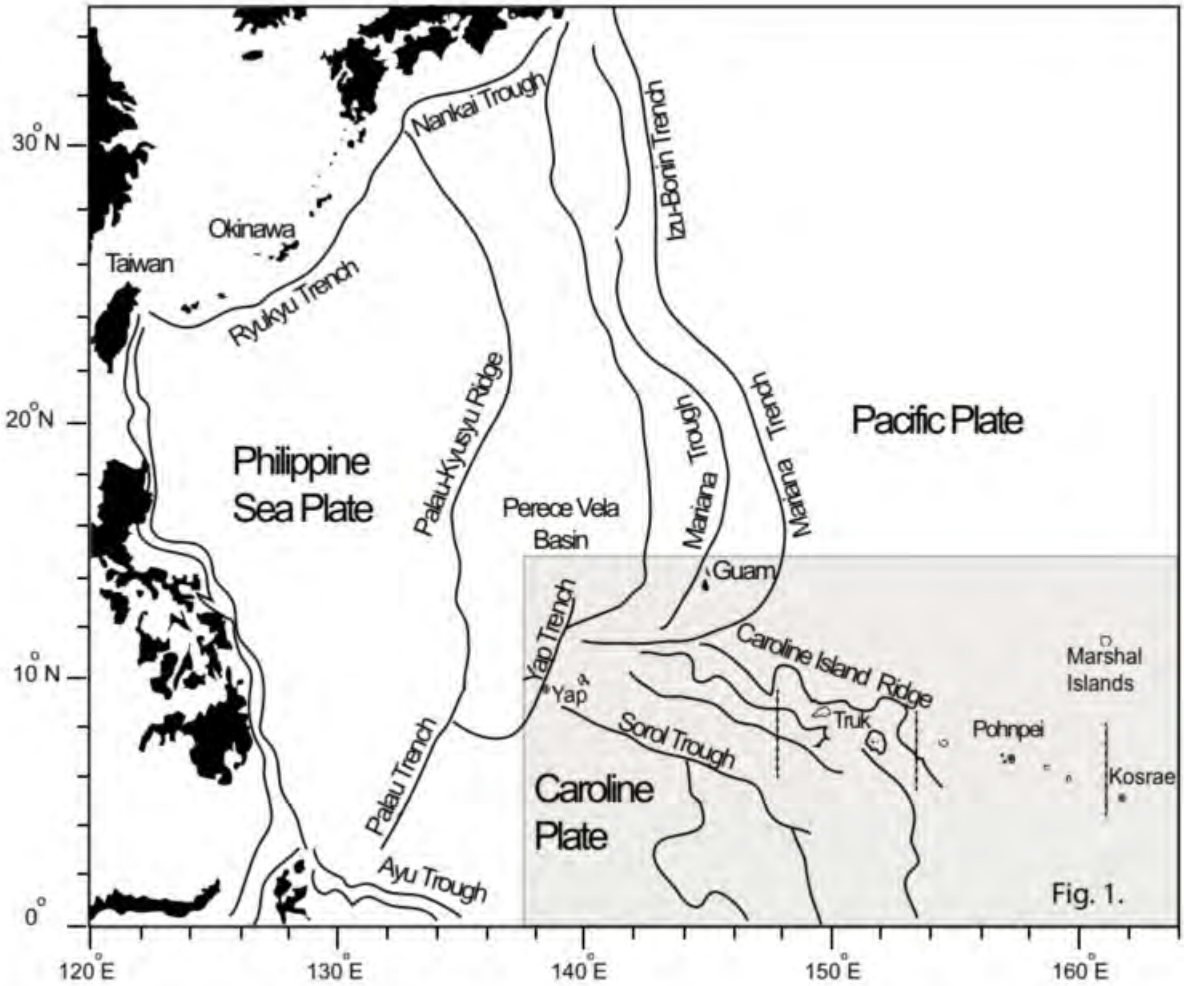
[33] Mattey, D. P. (1982). The Minor and Trace Element Geochemistry of Volcanic Rocks from Truk, Ponape and Kusaie, Eastern Caroline Islands: The Evolution of a Young Hot Spot Trace Across Old Pacific Ocean Crust. *Contributions to Mineralogy and Petrology*, 80:1–13.

[34] Rehman, H.U., Hideo, N. and Kawai, K. (2013). Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia, Western Pacific. *South Pacific Studies*, 33(2).

[35] US Geological Survey (1999). J. Tuzo Wilson: Discovering Transforms and Hotspots. https://pubs.usgs.gov/gip/dynamic/Wilson.html. Accessed 06/02/24.

[36] Menard, H.W. (1986). *Islands*. Published by Scientific American Library.

Figure 5: Simplified Sketch Map Illustrating the Tectonic Setting of the Four FSM states in Relationship to the Philippine Sea Plate and the Pacific Plate



Source: Rehman et al. 2013

Yap geology

The Yap islands are near the southern end of a submarine ridge named by Harry Hess in 1948 called the West Caroline Group anticline. This ridge is some 1,400 km in length trending east-northeast from Palau and turning north to the north of Yap. On the east side of Yap, the seafloor descends into the West Caroline trench and to the west it is bordered by the Philippine Basin. The basement rocks of the ridge are metamorphic of the amphibole and green schist facies with intrusive ultramafic rocks (see Figure 6).[37]

The basement rocks of Yap referred to as the Yap formation by Tayama (1935) are predominantly schists, phyllites, and massive rocks of the green schist and amphibolite metamorphorhic facies.

The Yap formation is a complex of metamorphic rocks of the greenschist and amphibolite with a considerable range in texture.[38] The formation includes chlorite-hornblende schist, hornblende schist, and other minor variations of these units. The chlorite-hornblende schist is green and is composed mainly of hornblende, which is partly or almost completely replaced by chlorite. The hornblende schist

[37] Johnson, C. G., Alvis, R. J., Hetzler, R. L. (1960). *Military Geology of Yap Islands, Caroline Islands*. Prepared under the direction of the Chief of Engineers, U.S. Army by the Intelligence Division, Office of the Engineer Headquarters United States Army Pacific with personnel of the United States Geological Survey, 1960.

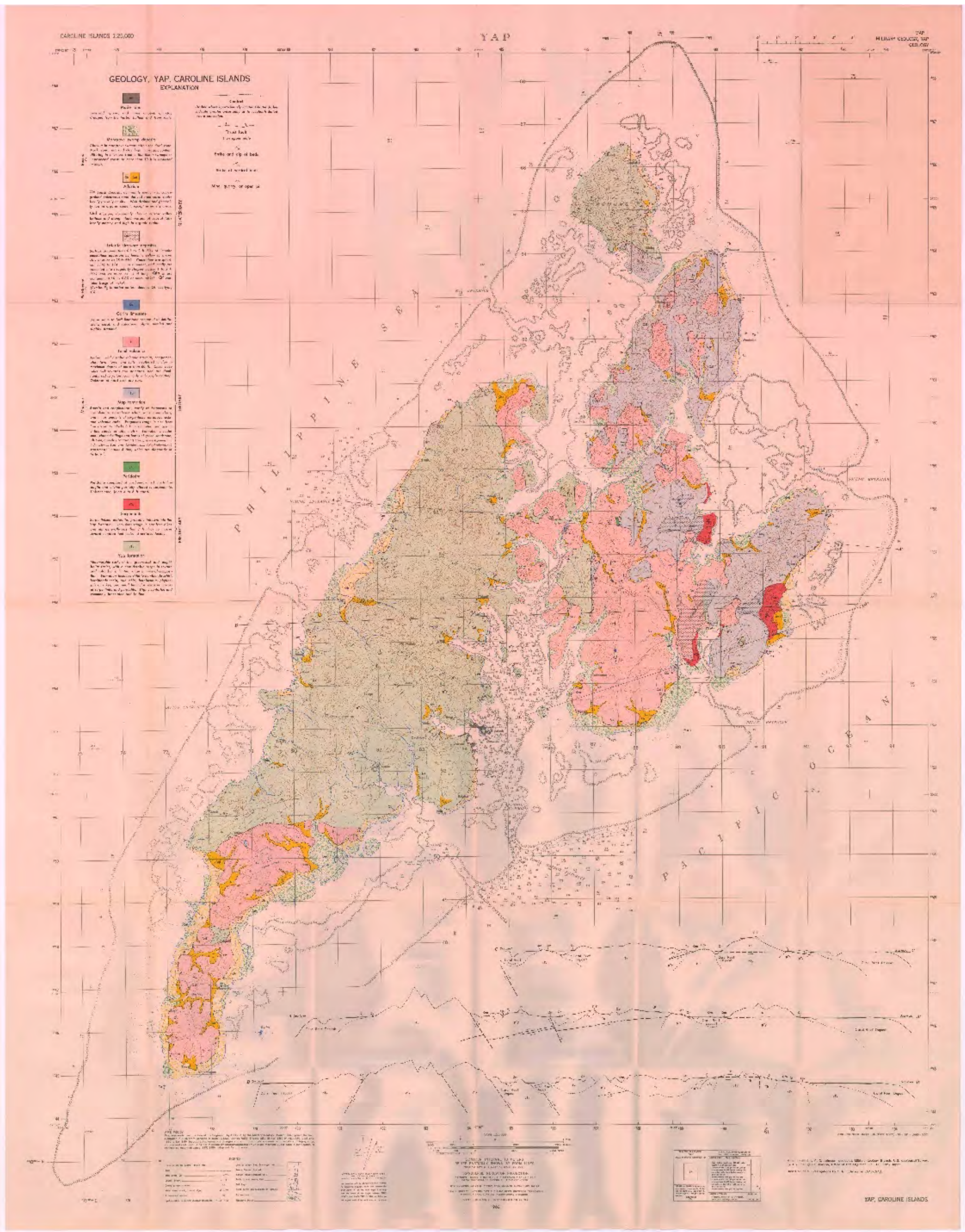
[38] Ibid.

is dark green to black and contains little or no chlorite. The rocks of the Yap formation weather to a flat clay which is gray to green-gray in color near the weathered rock surface. The formation is highly contorted and commonly brecciated and faulted.

Intrusive rocks are exposed in small outcrops in the northern and central parts of the island. In the south of Yap there is the Tomil volcanic group, andesitic tuffs, volcanic breccias, and lava flows that are almost completely weathered to clays. These overlie the breccia and the Yap basement rocks in the central and southern parts of the Yap islands.

Alluvial deposits of clay silt sand and gravel occupy valley bottoms, beaches, and mangrove swamps. Fringing reef surrounds the entire island group with breaks adjacent to the major drainage systems in the topography. Small outcrops of up-raised reef occur in the south of Yap on the fringing reef, with the age thought to range between Pleistocene to Recent.

Figure 6: Geology of Yap Island

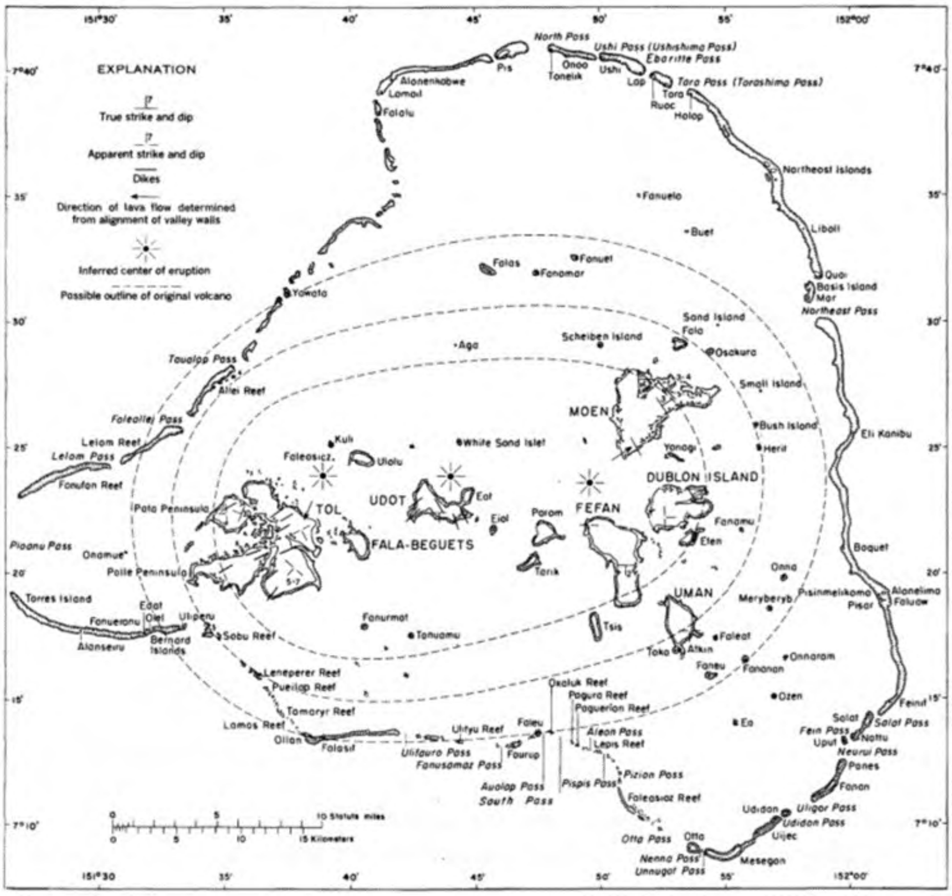


Source: Johnson et al. 1960

Chuuk geology

Chuuk State lies between latitudes 7° 8' and 7° 41' N and longitude 151° 26' and 152° 2' E. It comprises 12 elevated volcanic islands, the highest being over 250 m, and some 24 coral reef islands in a lagoon enclosed by a barrier reef forming an atoll-like structure.[39] In addition, there are 41 islands scattered along the atoll. Scholars have divided the volcanic islands into three subgroups, namely: 1) an eastern group comprising the islands of Moen, Weno, Uman, Dublon and Fefen; a central group with the islands of Udot, Eot and Eiol; and a western group comprising Tol, Fal-Beguets, and Ulalu.[40] These volcanic islands are remnants of a large shield volcano with dominant lava flows and minor pyroclastic deposits. The islands of the eastern group are characterized by olivine-basalts with minor andesite deposits. The central islands are mainly andesite and basalt with intermixed breccias. The rock on the islands of the western group is different from those of the eastern and central groups. For instance, Tol, the largest island in the western group, is entirely composed of olivine-basalt, nepheline basalt, and mililite-nepehleine-basalt, which suggests the group was produced by a different magma source (see Figure 7).[41]

Figure 7: Illustration of Three Island Groups in Chuuk and Probable Centers of Eruption



Source: Stark and Hay, 1963

[39] Rehman, H.U., Hideo, N. and Kawai, K. (2013). Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia, Western Pacific. *South Pacific Studies*, 33(2).

[40] Stark J. T. and Hay R. L. (1963). Geology and Petrography of Volcanic Rocks of the Truk Islands, East Caroline Islands. *Geological Survey Professional Paper* 409.

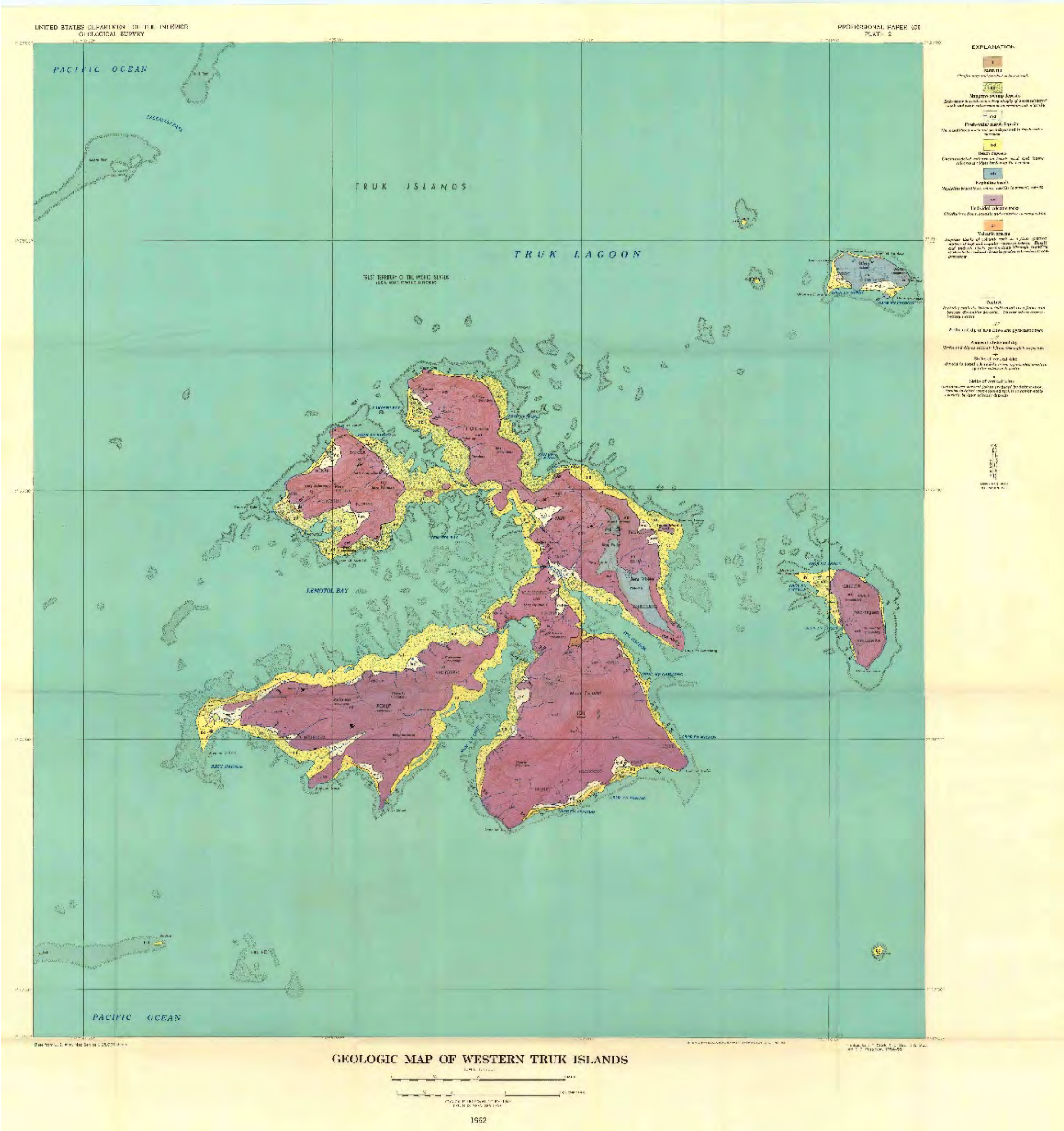
[41] Rehman, H.U., Hideo, N. and Kawai, K. (2013). Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia, Western Pacific. *South Pacific Studies*, 33(2).

Existing geological maps are shown in Figure 8 and Figure 9.

Figure 8: Geology of the Central and Eastern Group of Islands

Source: Stark et al. 1954-55

Figure 9: Geology of the Western Truk (Chuuk)



Source: Stark et al. 1958

Pohnpei geology

The island of Pohnpei lies at a latitude of 6° 54’ N and longitude of 158° 14’ E in the western Pacific. Pohnpei is a volcanic island surrounded by a coral reef, roughly circular in shape and has a land area of 338 km^2. The island is deeply dissected and characterized by steep topography.

The island of Pohnpei is the eroded remnant of a large shield volcano built up from the surrounding seafloor from numerous lava eruptions beginning about 9 million years ago.[42] These lavas are composed of basanite to alkali olivine basalt. Mapping undertaken in 1990 led researchers to conclude that the volcanic center was located north of the geographic center of the island and that

[42] Spengler, S.R. (1990). *Geology and Hydrogeology of the Island of Pohnpei, Federated States of Micronesia*. Ph.D. dissertation (Geology and Geophysics), University of Hawaii at Manoa, Honolulu.

the northern part of the shield volcano was removed by a catastrophic landslide into the ocean depths north of the island.

Towards the end of the shield-building phase eruptions became more explosive resulting in the southern half of the island being blanked with volcanic ash driven by strong northeasterly trade winds. The volcanic breccias exposed on the islands of Parem and Mwahnd resulted from blasts of pyroclastic material from nearby vents.[43]

Pohnpei's geological landscape is characterized by various rock types, including alkali olivine basalts, trachytes, hawaiites, ankramites, and nephlinites to basanites.[44] The rocks found on Pohnpei are finely grained volcanic basalt and have been subdivided according to their mineralogical composition. These subdivisions include alkali olivine basalts, trachytes (a lava corresponding in composition to synenite), ankramite (basalt rich in olivine and pyroxene), and nepheline (basalts lacking plagioclase and replaced with leutite and nepheline). Determining the mineral composition of these finer-grained rocks, such as Hawaiite, can be challenging, and are more often defined by their chemical, rather than mineralogical composition. These rocks are commonly observed as flows and shallow intrusives.

Research has indicated that there are three magma types in Pohnpei: (1) the Pohnpei Main Lava Series; (2) the Pohnpei Transitional Lava Series; and (3) the Pohnpei Basanite Series.[45] However, others have reclassified Pohnpei's volcanic rocks into two main types: shield building lavas and overlying post-shield deposits.[46] **Figure 10** is a sketch map of the geology of Pohnpei.

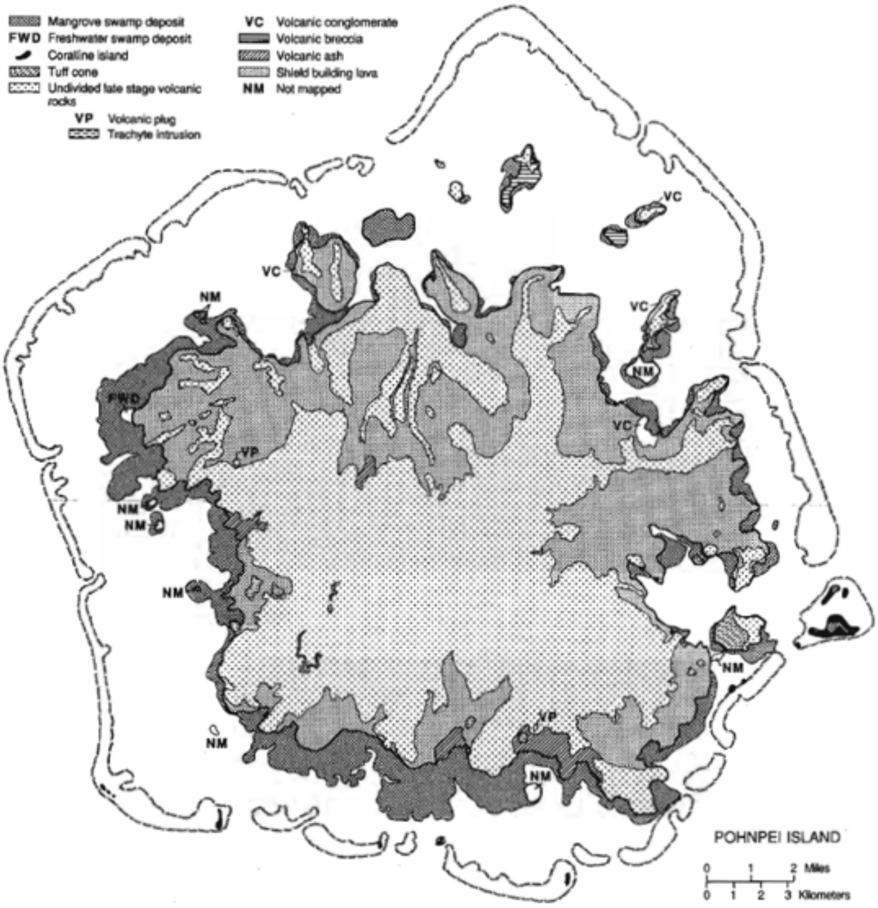
[43] Spengler, S.R. (1990). *Geology and Hydrogeology of the Island of Pohnpei, Federated States of Micronesia*. Ph.D. dissertation (Geology and Geophysics), University of Hawaii at Manoa, Honolulu.

[44] Rehman, H.U., Hideo, N. and Kawai, K. (2013). Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia, Western Pacific. *South Pacific Studies,* 33(2).

[45] Mattey, D. P. (1982). The Minor and Trace Element Geochemistry of Volcanic Rocks from Truk, Ponape and Kusaie, Eastern Caroline Islands: The Evolution of a Young Hot Spot Trace Across Old Pacific Ocean Crust. *Contributions to Mineralogy and Petrology*, 80:1–13.

[46] Spengler, S., Peterson, F., and Mink, J. (1991). *Geology and Hydrogeology of the island of Pohnpei, Federated States of Micronesia*. U.S. Department of the Interior, Geological Survey, March.

Figure 10. Geology Map of the Island of Pohnpei



Source: Spengler et al. 1991

Kosrae geology

Kosrae is the second-largest island in FSM after Pohnpei, and the most easterly state. It is a volcanic island surrounded by mangrove swamp. Albeit based on limited data, it has been reported that there are only two magma types on Kosrae ('Kusaie), namely (1) Kosrae Main Lava Series and (2) Kosrae Nepehlinite Series.[47] Kosrae Main Lava Series rocks are mainly basalts, ankaramites, and hawaiites that are similar to the Pohnpei main lava series basalts. Kosrae Nepehlinite Series rocks are a group of undersaturated lavas and dikes. There are currently no maps illustrating Kosrae's geology.

3.2.2 Summary of aggregate extraction sites and known resources

Yap aggregate resources

Yap is known to be resource-poor in terms of high-quality aggregate for infrastructure development. Although there are rivers on the island, these do not contain significant quantities of sand or gravel. Limestone outcrops do exist and although they are dense, the known deposits are very small and difficult to access. Completely absent in the geology of Yap is any fresh intrusive or extrusive

[47] Mattey, D. P. (1982). The Minor and Trace Element Geochemistry of Volcanic Rocks from Truk, Ponape and Kusaie, Eastern Caroline Islands: The Evolution of a Young Hot Spot Trace Across Old Pacific Ocean Crust. *Contributions to Mineralogy and Petrology*, 80:1–13.

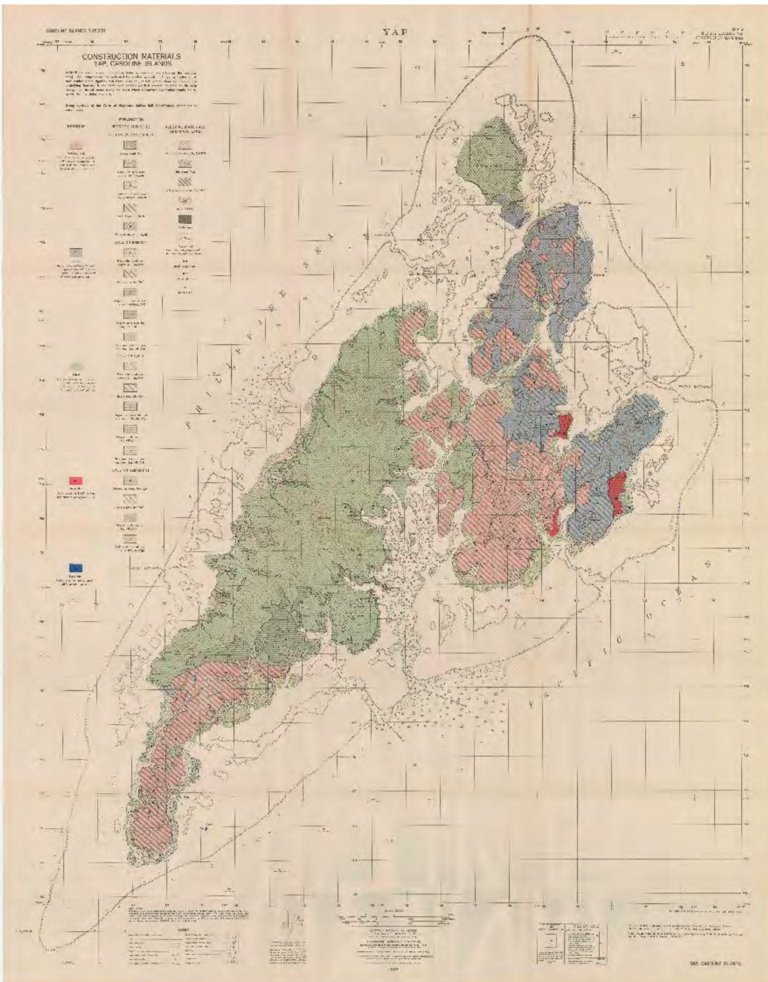
igneous bodies that would otherwise be considered a source to quarry for aggregate. Of the aggregate resources that are present, there are limited lenses of hard rock and breccia found in the dominate green schist faces and carbonate materials mined from the fringing reef.

The dominant soils of the island are generally described to range from silty to clayey sands, sandy silts and clayey silts.

Source material for riprap, be it heavy or light, although available has been reported to be difficult to access. Traditionally concrete aggregate has been sourced from the coral reef that surrounds the island. Road surfacing and base course material are often sourced also from the coral reefs. Materials are available almost everywhere, but they range from poor to good in terms of suitability.

The map in Figure 11 provides a base to illustrate the location of potential construction materials available on the island.

Figure 11: Yap Construction Materials Map



Source: Johnson et al. 1960

Coral aggregate dredging is commonplace in Yap. Figure 12 shows coral dredging taking place in 2001 south of the port in Kolonia. Currently there are no figures on consumption or annual demand for aggregates in Yap.

Figure 12: Coral Reef Dredging, Kolonia, Yap 2001

Photo credit: Robert Smith, 2001

Chuuk aggregate extraction sites, sourcing, and lagoonal resources

Several stratigraphic units have been considered good resources for aggregates.[48] Locations with hard rock in the form of lava flows have previously been considered good sites to quarry but with varying degrees of overburden. Relevant stratigraphic units mapped and described in 1958 included:[49]

Unit 2: Hard mixed lavas. Bare rock exposed of series of hard, dark grey heterogeneous basalt and andesite lava flows, of various hardness and composition with scattered, inter bedded, indurated, pyroclastic breccia lenses. Columnar jointing general and dike locally common. Exposed in cliffs and on rocky hill crests.

Unit 10: Shallow to deep clays on hard compact lavas.

Unit 13: shallow to deep limonitic clays that overly moderately hard lavas.

Historically, there existed sizeable quarries in the Chuuk Islands where extensive amounts of bedrock had been excavated.[50] These quarries can be traced back to the Japanese occupation in World War II. Three quarries were located on Weno (Moen) Island. On Tonowas (formerly called Dublon Island),

[48] Stark J. T. and Hay R. L. (1963). Geology and Petrography of Volcanic Rocks of the Truk Islands, East Caroline Islands. *Geological Survey Professional Paper* 409.

[49] Stark, John T., James E. Paseur, Richard L. Hay, Harold G. May and Elmer D. Patterson (1958). Military Geology of Truk Islands, Caroline Islands. Intelligence Division, Office of the Engineer, U.S. Army Pacific Headquarters. 205 pp. (MARC).

[50] Ibid.

Uman and Param, field boulders for crushing into aggregate had also been collected during the period of Japanese occupation.

Coastal borrow pits were dug by the Japanese at the base of coastal slopes on the west and south of Tonowas and can still be seen today. On the south side of Parem, three borrow pits were cut into the slope, as well as a long bench at the edge of the airfield.[51] On the island of Etten, the Japanese benched the whole north slope of the island ridge to provide fill for the airfield site.

There is currently a small hard rock quarry operating in Tonowas owned by the owners of Blue Lagoon hotel (Figure 13). A second quarry is located opposite the Kurresa hotel in Weno Island (Figure 14) but may not be currently operational due to the owner's ill health. The crusher plant was reported to be looking dilapidated.

About 4 years ago, a company from Guam did some major concreting works on the airport apron and an open drain beside the road near the Level5 hotel. It is believed the company brought all of the aggregates required from Guam.

Figure 13. Crusher Site and Quarry Stockpile on Tonowas Island in Chuuk

Photo credit: F. Vukikomoala, SPC Pohnpei Jan 2023

[51] Ibid.

Figure 14. Rock Quarry Located Opposite the Kurrasa Hotel in Weno, Chuuk

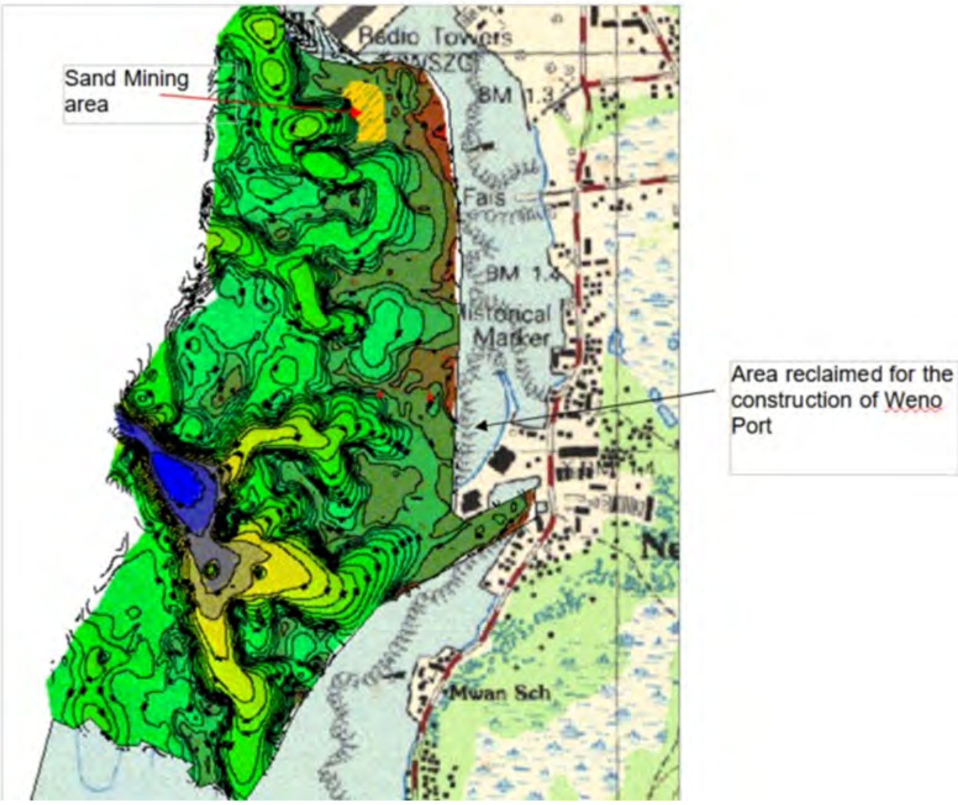
Photo credit: F. Vukikomoala, SPC, Pohnpei Jan 2023

Sand Mining

A study in 2002 reported evidence of previous sand mining in Chuuk in an area of shallow shelf with an average depth of 9 m at the head of a submarine canyon.[52] Interpretation of the dredging scars or pot marks seen in a multibeam data set showed that the clam shell operation reached a depth of about 4 m below the seabed with numerous scars on the seabed evident. **FIgure 15** is a bathymetry map of the sand mining area in the lagoon. Also noteworthy was the extensive mining of the reef as evident in Figure 16 east of the end of the runway on Weno (photo on right). The current status of sand mining in Chuuk is not known.

[52] Smith, R. (2002). Multibeam Survey -Chuuk Lagoon, Chuuk State, Federated States of Micronesia. *SOPAC Technical Report* 367.

Figure 15: Weno Harbor Bathymetry Merged with a Georeferenced Image of the 1:25,000 Topographic Map



Source: Smith, 2002

Figure 16: Sand and Coral Mining on Weno Island

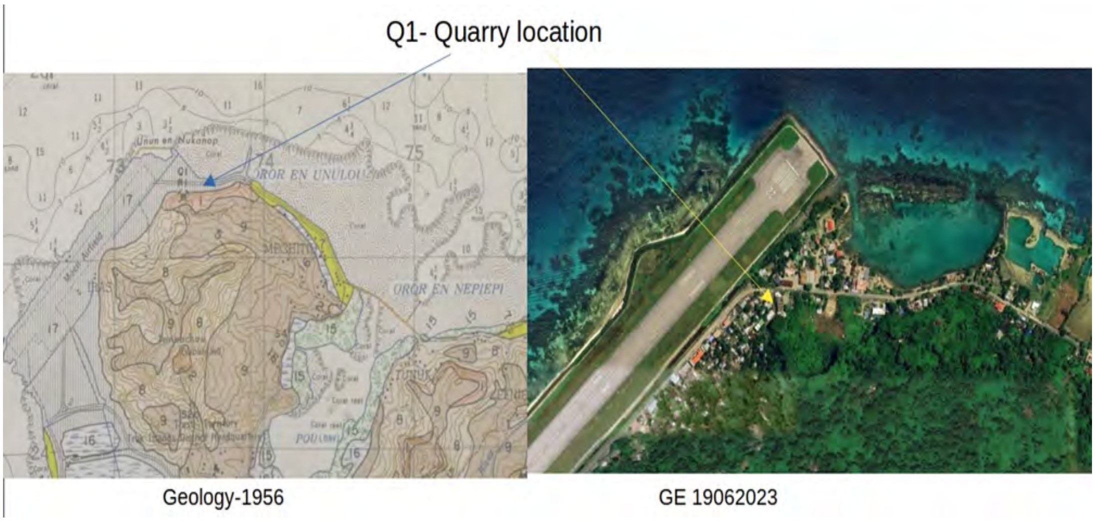
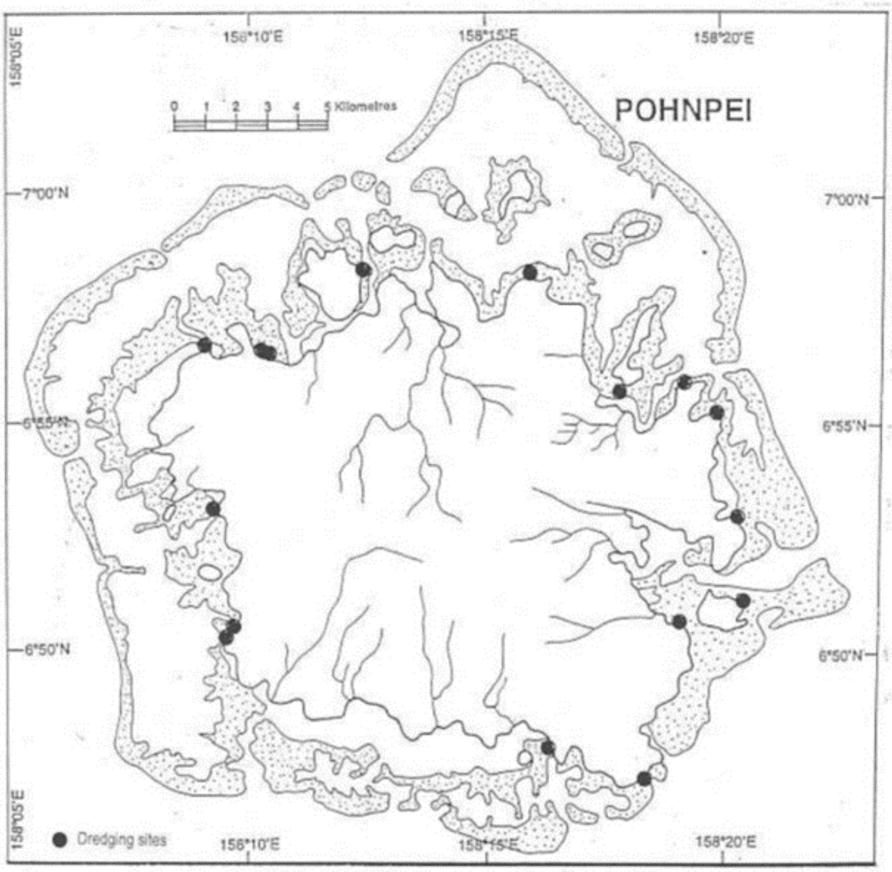


Photo credit: Smith, 2002

Pohnpei current aggregate extraction sites, sourcing, and lagoonal resources

Coral reef mining was for many years the main source of construction aggregates for domestic and industrial purposes; however, this practice has resulted in degradation of many areas of Pohnpei's fringing reef surrounding the island. Impacts of this dredging of the nearshore fringing reef environment have led to modification of the seabed bathymetry, which, in turn, has altered the hydrodynamic regime and impacted circulation and water quality, with excessive turbidity generated from dredging. Excessive turbidity affects reef growth and the problem of abandoned pits, with their haphazard geometry, add to the difficulties of site rehabilitation.[53] Figure 17 illustrates the extent of reef dredging sites in 1997.

Figure 17: Pohnpei Reef Dredge Sites 1997



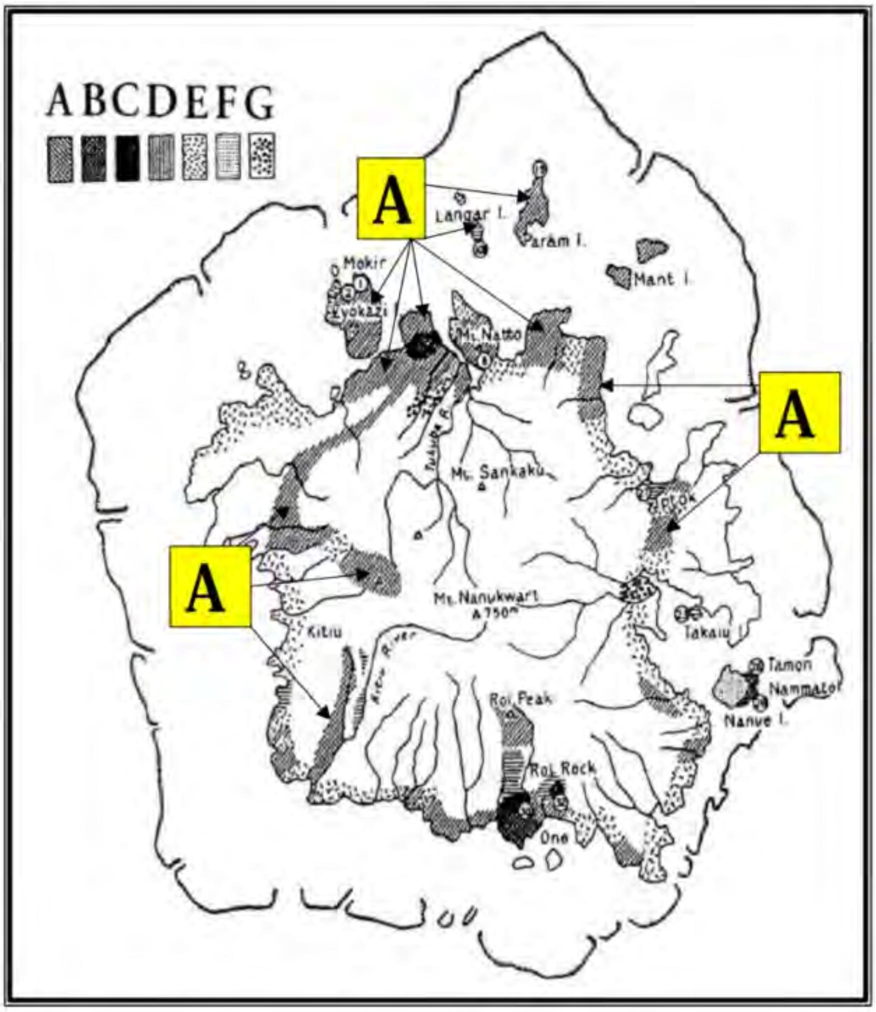
Source: Edward et al. 1997

Several SOPAC reports by Maharaj in 1999 provide a geological assessment of onshore aggregate potential, as well as the engineering properties of rocks collected during field mapping.[54] The best lithologies for quarrying and engineering applications were those rocks shown in Zones A and B in themapin Figure 18 whichareassociatedwith basaltsalongtheperiphery of the island. These are primarily columnar, fine-grained, grey-green fresh olivine basalts.

[53] Edward, A., Hellan, E., Smith, R. and Howarth, R. (1997). Pohnpei Lagoon Dredging: Strategy for Developing a Work Program to Assist with the Development of Guidelines and Legislation. *SOPAC Miscellaneous Report* 247: 1–12.

[54] Maharaj R.J. (1999). Engineering Geological Assessment of Onshore Aggregate Potential, Pohnpei Island, Federated States of Micronesia (FSM). Suva, Fiji: SOPAC. p. 50. https://purl.org/spc/digilib/doc/8zs5e; Maharaj R.J. (1999). Assessment of Onshore Aggregate Resources, Pohnpei, Federated States of Micronesia (FSM). Suva, Fiji: SOPAC. p. 20 https://purl.org/spc/digilib/doc/dhb7e.

Figure 18: Sketch Map Illustrating Different Lithographies with Location of Rock Samples Analyzed in Pohnpei



Source: Maharaj 1999a

A study in 1999 documented two quarry sites: the APSCO Quarry in Sokehs, which is still operating.[55] A second abandoned site also in Sokehs that had reportedly been operated by a Republic of Korea firm was also looked at.

Currently, there are at least two operational quarries in Pohnpei. The Sokehs site operated by APSCO Quarry and the VCS Quarry in Metilenium (**Figure 19**), with the beneficiation site located on the east side of the causeway leading to the port and airport (**Figure 20**). A third site operated by a People's Republic of China (PRC) company as part of a road works project in Metilenum was operating in 2021.

[55] Maharaj R.J. (1999). Assessment of Onshore Aggregate Resources, Pohnpei, Federated States of Micronesia (FSM). Suva, Fiji: SOPAC. p. 20 https://purl.org/spc/digilib/doc/dhb7e.

Figure 19: Location of Quarry, Crushers, and Sand Mining Operations in Kolonia

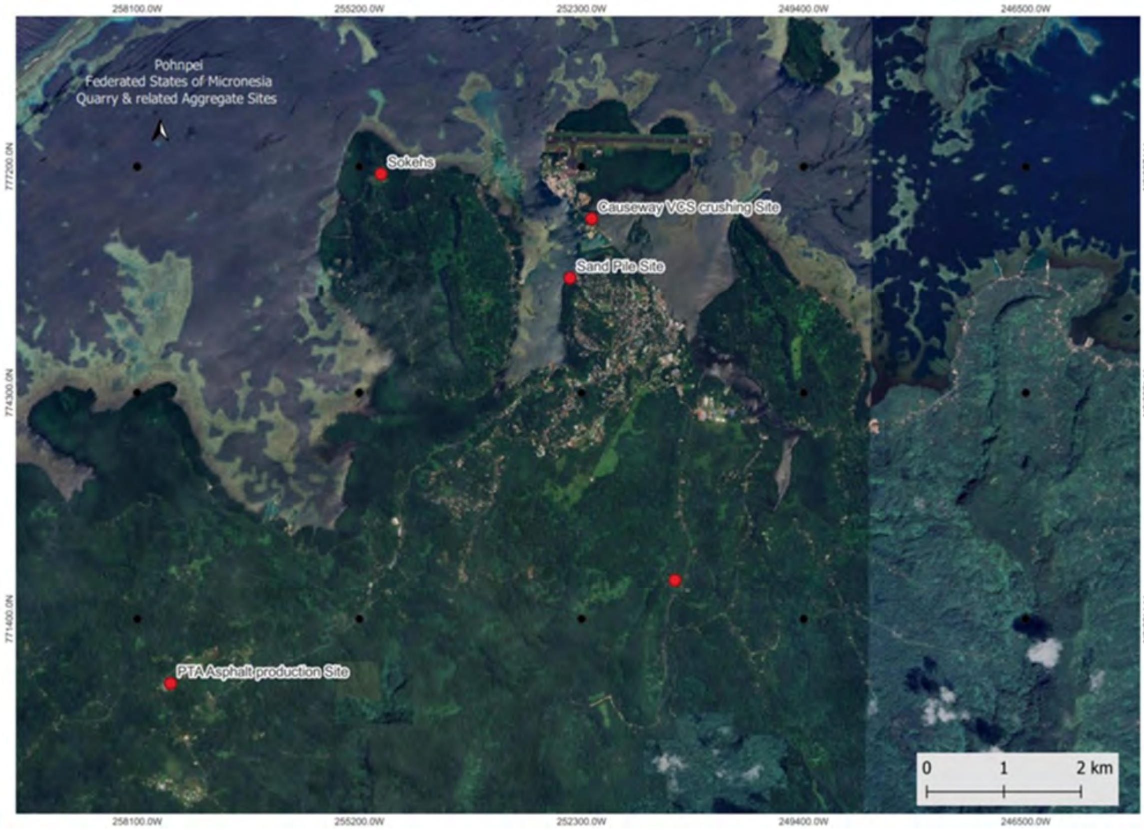


Photo credit: Keleni Raqisia September 2023, image backdrop from Google Earth 28-06-2023

Figure 20: VCS Crusher Site Located on the East Side of the Causeway Leading to the Airport and Port

Source: Google Earth 28 June 2023

Figure 21 is a time series of the Sokehs quarry run by APSCO in Pohnpei, w hich may be the longest- operating quarry since the early 1990s. Based on the images, this greening of the quarry site in the 2023 Google Earth image may be suggestive of diminished rock resources or site difficulties.

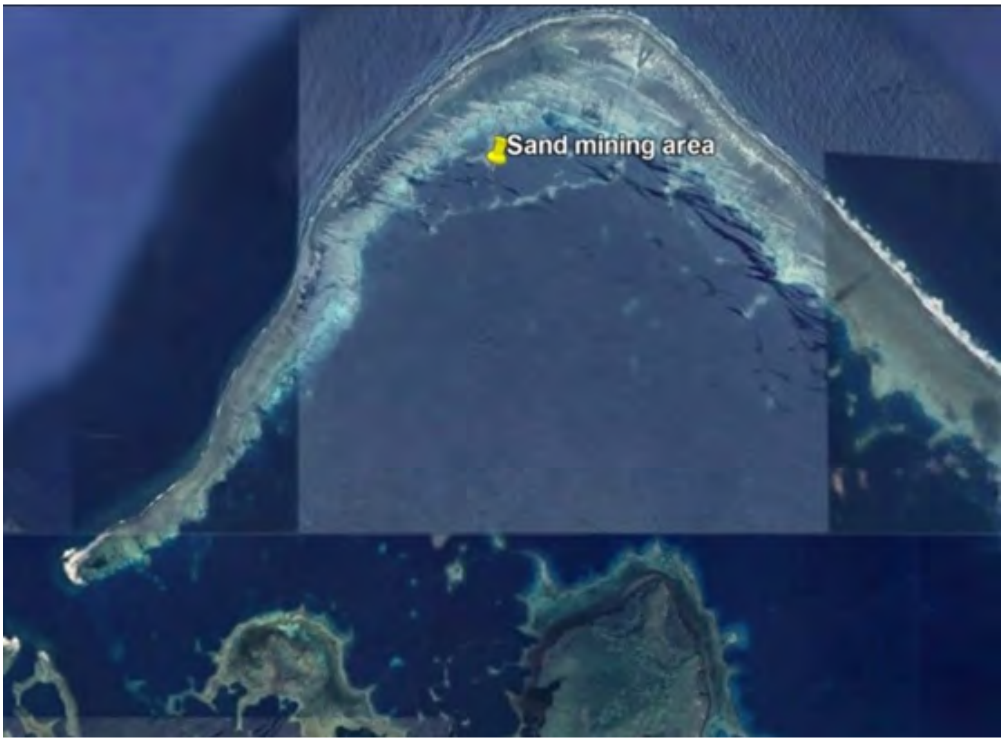
Figure 21: Time Series of the Sokehs APSCO Quarry Showing a Greening of the Site in 2023

Source: Compiled by Robert Smith using Google Earth imagery

Sand mining was done in the north of the lagoon in Nett Municipality (**Figure 22**). In a 1997 study, this area was mapped to determine likely sand reserves.[56] Results of that survey estimated reserves of around 360,000 m^3, which could supply Pohnpei for 30 years. Extraction rates in 1997 were around 12,000 m^3 per annum. The base for the mined sand was stockpiled in Kolonia harbor (Figure 23). Today, VCS is the sole provider of coral sand in Pohnpei.

[56] Smith, R., Edward, A., Shorten, G. (1997). Sand Dredging, Nett Municipality, Pohnpei Lagoon, Federated States of Micronesia: Resource Assessment and Environmental Considerations. *SOPAC Technical Report* 244.

Figure 22: Sand Mining Area in the North of the Lagoon in Nett Municipality. This Area Was Mapped in 1997



Source: Google Earth Imagery

Figure 23: VCS Sand Mining, Kolonia, Pohnpei

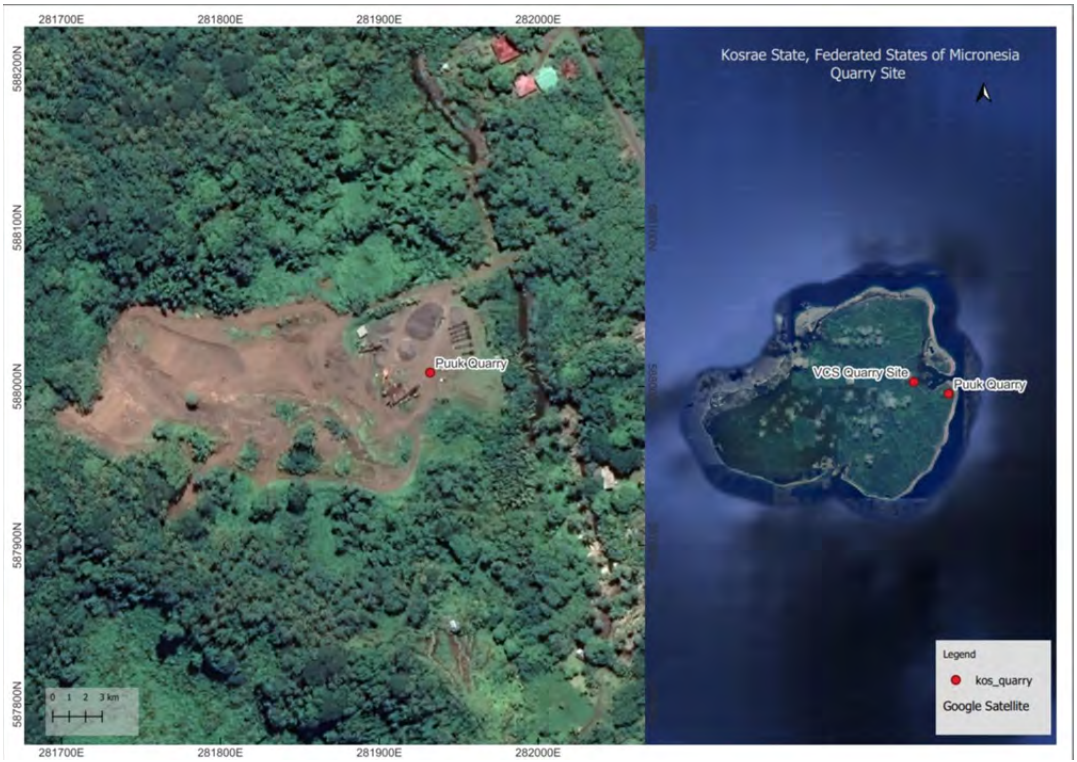
Source: Smith et al. 1997

The 1997 study was unable to obtain figures for annual sand consumption in Pohnpei. Inquires with two of three known companies active in dredging at the time supplying sand suggested an estimated annual consumption of around 11,500 m^3. Based on figures compiled for other places in the Pacific where better datasets are available for a similar population size and population growth rates, this figure is not unreasonable, although annual consumption could be as high as 20,000 m^3 per year. With the little available data at that time, it was concluded that the reserves available at the mining site would last between 15 and 30 years. However, it is not known how much of this resource has been extracted since the time of the study, some 26 years ago. The study also did not consider continued reef productivity or issues of sustainability.

Kosrae aggregate extraction sites

There are two known operational rock quarries in Kosrae as shown in Figure 24. Of these, one is run by a former governor and the other, the Puk Quarry, is Kosrae's largest and is owned by VCS, headquartered in Pohnpei (Figure 25 and Figure 26, respectively). The Puk Quarry is reportedly able to produce around 55 cubic meters of gravel and black sand per day.[57] There was no further information on these quarries or other extraction sites at the timing of writing.

Figure 24. Location of Quarry Sites on Kosrae



Map credit: Keleni Raqisia, SPC, Pohnpei September 2023

[57] George, A. and Skilling, T. (2021). Island Diagnostic Analysis Report for Kosrae State, Federated States of Micronesia. *GEF Pacific International Waters Ridge to Reef Regional Project*, Pacific Community (SPC), Suva, Fiji.

Figure 25: Former Governor's Quarry on Kosrae

Photo credit: F. Vukikomoala SPC, Pohnpei, September 2023

Figure 26: VCS Quarry, Kosrae

Photo credit: F. Vukikomoala, SPC Pohnpei. September 2023

3.2.3 Aggregates required in the national infrastructure plan for FSM

Infrastructure Development Plan 2016–2025

FSM's infrastructure needs are outlined in its National Infrastructure Development Plan, which covers 2016–2025 (Table 6).[58] The 10-year plan covers 10 infrastructure sectors in all the four states at a cost of $1.082 billion. The large scale of this investment and the type of projects to be developed require a significant quantity of aggregates, though some 9 years into the plan there have been no reports of major shortages that are impeding development.

Table 6: FSM National Infrastructure Development Plan, 2016–2025

Sector	Planned Infrastructure Investment ($ million)					
	National	Chuuk	Kosrae	Pohnpei	Yap	Total
Electric Power	-	7.8	17.6	62.6	7.1	**95.1**
Water/Wastewater Systems	-	7.0	14.6	35.7	16.8	**74.1**
Solid Waste Management	-	3.5	0.3	4.5	3.7	**12.0**
Road and Pedestrian Facilities	-	95.0	51.0	45.0	18.1	**209.0**
Maritime Transportation	-	8.5	21.6	6.7	41.9	**78.7**
Air Transportation	0.5	34.2	31.0	0.6	32.8	**99.1**
Telecommunications	13.4	-	-	-	-	**13.4**
Education	69.3	44.7	3.0	73.1	15.7	**205.8**
Health	-	73.0	18.5	15.3	1.7	**108.5**
Government Administrative Buildings	28.1	-	1.1	5.2	16.9	**51.3**
Climate Change Adaptation	-	-	-	-	4.0	**4.0**
Program Management	7.5	10.0	4.0	5.0	4.0	**30.5**
Subtotal:	**118.7**	**283.7**	**162.7**	**253.8**	**162.4**	**981.4**
Institutional	2.4	2.0	-	-	-	**4.4**
Infrastructure Maintenance	1.2	40.6	12.6	25.5	16.3	**96.2**
Total Infrastructure Investment:	**122.3**	**326.3**	**175.3**	**279.3**	**178.7**	**1,082.0**

Source: FSM's Infrastructure Development Plan 2016–2025

Consultations with infrastructure developers and government reveal that there are several significant projects currently underway, most likely implemented under the National Infrastructure Development Plan. These include:

Nationwide: a World Bank project to replace several bridges in FSM under a climate resilience improvement works for identified network assets.

Pohnpei: the 12 m long Awak Bridge is to be replaced.

Kosrae improving the Lelu causeway. Lelu is the most populated area in Kosrae but, as it is an island, the causeway is the only link to the mainland. The causeway was constructed some 50 years ago, is narrow, of low elevation, and is suffering from erosion and tidal scouring.

Chuuk improvement to the road from the airport to Pou Bay Bridge. This 2.5 km stretch of road is in extremely poor condition, with waterlogged potholes that make it barely passable. The road forms a

[58] FSM National Infrastructure Development Plan, 2016–2025. https://dofa.gov.fm/wp-content/uploads/2018/12/FSM-Infrastructure-Development-Plan-2016-2025.pdf. Accessed 19/10/2023.

primary link between Weno town and the communities and facilities at Sapuk. Concrete is being considered.

Yap: Two bridge replacements at Manta Ray, Donoch, and Tagaaniyali. The two 6 m long steel and concrete bridges in Kolonia are located directly on the shoreline. These bridges have weight limits.

Going forward, PRIF members have identified five key infrastructure projects, as summarized in Table 7. These projects are estimated to cost $118.5 million. Additional capacity-building projects with a value of $6.9 million are not included in the table. These projects would likely require moderate quantities of aggregate relative to other PICs, particularly for the road and port projects, which will require aggregate for road pavement and concrete.

Table 7: Infrastructure Projects Identified by PRIF Members for FSM and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Sustainable Road Infrastructure Investment Project	20.0	High	Requires large volumes of aggregates for concrete, asphalt, and pavement layers (dependent on design and specifications).
Transport	Pohnpei Port Expansion	25.0	High	Requires large volumes of aggregates for concrete and boulders for breakwaters, and other facilities
Energy	Climate-Resilient Energy and Water Projects	43.0	Moderate- high	Requires moderate to high amounts of aggregates depending on the final work scope
Water and sanitation	Chuuk Water Supply and Sanitation Project	10.5 (additional financing)	Moderate	Requires moderate volumes of aggregates for concrete, and sand for water treatment. Likely to involve the construction of reservoirs, pumping stations, treatment plants, and pipelines among others.
ICT	East Micronesia Cable - FSM, Kiribati, Nauru (w/ Japan, Australia, and US)	20 (with additional 1 million TA)	TBC	Demand TBC pending further information on project scope
Total ($)		**118.5**		

Source: PRIF 2023; relevant project reports where available

3.2.4 Overview of the legal and policy framework

FSM is a constitutional democracy with an overarching national government retaining responsibility for 18 specific functions, as identified in the Constitution (Article IX, Sect. 2).[59] This includes such things as foreign affairs, defense, imposition of taxation, education and health, and negotiating and entering into multilateral agreements, including those relating to the environment. All other government functions are delegated to the state governments. The national government is based in Palikir, Pohnpei, and is comprised of executive, legislative, and judicial branches. Although FSM's Constitution states that it is the "supreme law of the Federated States of Micronesia" (Article II Sect.

[59] Constitution of the Federated States of Micronesia, 1981 with amendments through 1990.

https://www.fao.org/faolex/results/details/en/c/LEX-FAOC129980. Accessed 19/10/2023.

1, each of the four states also has its own constitution, as well as elected legislature and governors, and have the power to function as a semi-autonomous government.

Land and resource ownership

FSM's Constitution prohibits the ownership of land by non-FSM citizens, including domestic companies with foreign shareholders (Article VIII, Sect. 4. All states allow land transfer to other citizens of FSM with the exception of Pohnpei, where it can only be transferred to people from that island. Throughout the country, traditional systems of land tenure are still prevalent and are characterized by communal and group control over land but with regional variations.[60] Traditionally, land ownership was obtained through inheritance from a family or clan. Many land parcels are therefore subject to communal use but in practice private landholders occupy most land, subject to customary rules.[61]

It has been estimated that 65% of all land in FSM is communal land (but with much privately occupied, 35% public land (e.g., owned by provincial and local governments, and less than 1% freehold land.[62] The particularities of public and private land ownership, including ownership of aquatic areas, vary across FSM's four states. For example, in Pohnpei and Kosrae land is privately and publicly owned but aquatic areas are managed by the state as public trusts.[63] In Chuuk, most land and aquatic areas are privately owned, having been acquired through inheritance, purchase, and gift.[64] Meanwhile, in Yap, land and aquatic areas are owned by individual estates, meaning they can be individually owned, rented,[65] or used though customary rules. Despite years of cadastral survey and registration programs, large areas of land in FSM remain unregistered.

The Constitution gives FSM's Congress the power "to regulate the ownership, exploration, and exploitation of natural resources within the marine space of the Federated States of Micronesia beyond 12 miles from the island baselines", while the state governments have sovereignty over the territorial sea, i.e., within 12 miles from islands. However, with a few exceptions, provisions for land matters are absent from the Constitution, which has the effect of giving authority over land to the individual states. The states also effectively have exclusive power to regulate the environment and conservation in their respective jurisdictions.

Table 8 summarizes the various laws and policies as they relate to land matters in each of the four states, as well as those that have a direct bearing on the extraction of aggregate resources.

Table 8: Summary of Acts and Policies Relevant to Aggregate Extraction

Act / policy	Description	Relevance to aggregates sector
	NATIONAL	
Constitution of the Federated States of Micronesia	"The Supreme Law" of FSM declares that Congress has the power to regulate the	No further mention of natural resources, only brief mention of mineral

[60] Doran, K. (2004). *Private Lands Conservation in the Federated States of Micronesia*. Natural Resources Law Centre, University of Colorado School of Law.

[61] Ibid.

[62] Juswanto, W., and Kelkar, V. (2019). *The Dynamics of Urbanization, Housing, and Land Provision in the Pacific Island Countries*. ADB Policy Institute Policy Brief.

[63] Doran, K. (2004). *Private Lands Conservation in the Federated States of Micronesia*. Natural Resources Law Centre, University of Colorado School of Law.

[64] Ibid.

[65] For example, even where land is owned by one person, there may be other parties who own or use fruit trees through customary rules of access.

Act / policy	Description	Relevance to aggregates sector
	ownership, exploration, and exploitation of natural resources within the marine space of the Federated States of Micronesia beyond 12 miles from the island baselines.	resources on the ocean floor being divided "equally between the national government and the appropriate state government" (Art. IX Sect. 6.). Constitution effectively delegates control of land matters to the States.
Subtitles 1 and 2 of Title 25 of the Federated States of Micronesia Environmental Protection Act (1980, 2001).	Very basic and brief coverage of environmental protection, covering things such public policy, definitions etc. A copy of the full Environmental Protect Act of 2015 is not publicly available.	These 'subtitles' of the act do not mention minerals or aggregates but, by the nature of the act, do have indirect relevance since they provide for the preservation and protection of the environment from all activities, including exploitation of natural resources.
Federated States of Micronesia Climate Change Act 2013[66]	Introduces a new chapter into Title 25 of the Code of the Federated States of Micronesia. This act requires departments and agencies to prepare plans and policies to support FSM's Climate Change Policy. The act also tasks the Office of Environment and Emergency Management to coordinate and implement Climate Change Policy.	No reference to minerals or natural resources though it is likely policies and programs to build climate resilience (e.g., construction of seawalls) would have direct implications for supply of aggregates, concrete etc.
Marine Fisheries Act (2002)[67]	This act amends Title 24 of the Code of the Federated States of Micronesia to provide for the sustainable development, conservation, and use of FSM's marine resources.	Focus is on fisheries and other marine resources. There is no discussion of mineral resources in marine areas such as sand, gravel.
Earthmoving Regulations, 1988[68]	Regulations apply to any activity that "disturbs or alters the surface of the land, coral reef or bottom of lagoons". Regulations are intended to prevent erosion and sedimentation caused by earth moving and require management measures to prevent adverse impacts.	Definition of earthmoving includes activities that disturb or alter the surface of the land, a coral reef, or bottom of a lagoon. This would include aggregate extraction e.g., through dredging, land reclamation in a lagoon, mineral extraction etc.
Nationwide Climate Change Policy[69]	This is a national plan that takes a sectoral approach to climate change mitigation and adaptation and to reduce the vulnerability of Micronesia to adverse climate impacts.	General policy only without specific mention of mining, quarrying etc.
National Biodiversity Action Plan, 2018-2023[70]	Provides a roadmap for protecting biodiversity against various threats such as environmental degradation, over-exploitation of resources and climate change etc.	Mining is identified as a potential threat to biodiversity, though quarrying is not mentioned. Coastal degradation and erosion also identified as specific threats.
National Disaster Response Plan, 2016[71]	This is a national plan that takes a sectoral approach to disaster response. The Plan aims to strengthen operational structures for responding to natural disasters at national, state, and local levels, including at the village and outer island levels. It also allocates responsibilities for disaster response, sets	The Plan does not directly deal with aggregates or other mineral resources but does mention the need to coordinate support for disaster-affected communities in the reconstruction of physical infrastructure.

[66] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC155925. Accessed 23/10/2023.

[67] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC050750. Accessed 24/10/2023.

[68] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC037794. Accessed 26/10/2023.

[69] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC183172. Accessed 25/10/2023.

[70] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC214260. Accessed 25/10/2023.

[71] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC185715. Accessed 25/10/2023.

Act / policy	Description	Relevance to aggregates sector
	arrangements for aligning with regional and US associations in relation to disaster management.	
Environmental Impact Assessment Regulations 1996[72]	Describes responsibilities and processes and contents required in an EIA.	Does not explicitly mention minerals, mineral extraction or quarrying though regulations would clearly apply to these activities.
	YAP	
Yap State Constitution[73]	Constitution is the "Supreme Law" of the State and takes priority over all other laws.	Very brief mention of the protection, conservation and sustainable development of minerals and other natural resources.
Chapter 1 of Title 9 of the Yap State Code - Public Land, 1987[74]	Law makes provision for the control of public land by the state. Includes land conveyance to state govt and by the state govt. to other parties, such as through sale, grant, long-term lease etc.	No mention of minerals, natural resources or aggregates. Land conveyed for development must be accompanied by an EIA. This would presumably include mining operations.
Regulations for Earthmoving and Sedimentation Control (Title X, Chapter 1)[75]	These regulations are made by the Yap Environmental Protection Agency (EPA) under the Yap State Environmental Quality Protection Act. They apply to all earth moving activities and are intended to prevent erosion and sedimentation caused by earth moving and require management measures to prevent adverse impacts.	Definition of earthmoving includes activities that disturb or alter the surface of the land, a coral reef, or bottom of a lagoon. This would include aggregate extraction e.g., through dredging, land reclamation in a lagoon, mineral extraction etc.
Chapter 11 of Title 18 of the Yap State Code - Environmental Quality Protection Act, 1987	Provides for protection of the environment in Yap, including establishment of the State Environmental Protection Agency, requirement for Environmental Impact Studies etc.	References Art. XII, Sect. 1 of state constitution, and protection, conservation, and sustainable development of minerals etc.
Yap Joint State Action Plan for Disaster Risk Management and Climate Change[76]	State level policy that provides strategic priority actions to address disaster and climate related risks across all sectors and parts of the community.	Identifies that beach mining (sand, gravel, cobbles) for construction aggregates, removal of sand and coral from the reef flat, and dredging of the reef can increase vulnerability and worsen impacts of coastal hazards.
	CHUUK	
Chuuk: Chapter 2 of Title 57 of the Trust Territory Code - Land Ownership Generally[77]	This chapter of the Trust Territory Code restricts land ownership to residents of FSM – land may not be owned by foreigners.	No specific coverage of aggregates though clearly would have implications for ownership of quarry operations on customary land.
Chapter 1 of Title 22 of the Chuuk State Code - Chuuk State Environmental Protection Act[78]	Provides for environmental protection policy in Chuuk, as well as environmental protection measures and establishment of the EPA.	No specific coverage of mineral / aggregate extraction, though there are requirements for environmental impact statements for activities such as "resource exploitation" that "may substantially affect the quality of the environment".

[72] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC037816. Accessed 23/10/2023.

[73] Available https://www.fsmlaw.org/yap/constitution/entire.htm. Accessed 23/10/2023.

[74] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079207. Accessed 23/10/2023.

[75] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC121181. Accessed 26/10/2023.

[76] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC185803. Accessed 23/10/2023.

[77] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC078969. Accessed 26/10/2063.

[78] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC078934. Accessed 26/10/2023.

Act / policy	Description	Relevance to aggregates sector
Chuuk Joint State Action Plan on Disaster Risk Management and Climate Change[79]	This is a state-based plan aimed at protecting livelihoods and the environment from disaster and climate related risks.	No specific coverage of mineral / aggregate extraction.
Chapter 11 of Title 24 of the Chuuk State Code - Public Lands and Condemnation.	This Chapter of the State Code makes provision for compulsory land acquisition and in Chuuk. It includes processes for determining compensation, as well as resolution of disputes.	No specific coverage of mineral / aggregate extraction.
Chuuk: Chapter 9 of Title 67 of the Trust Territory Code - Land Acquisition.	This Chapter of the Code sets out procedures for government acquisition of real property.	No specific coverage of mineral / aggregate extraction.
	POHNPEI	
Chapter 9 of Title 42 of the Pohnpei State Code - Mining and Dredging[80]	Authorizes the Public Lands Board of Trustees to regulate the removal of mined and dredged materials located on Public Trust Lands. Dredging and removal of dredged material at any other site is prohibited. The chapter outlines the conditions for the mining of sand in marine areas. Monitoring is required by the EPA and the Division of Forestry and Marine Conservation. The chapter also establishes certain conditions for mining and dredging in general. Permits of these activities are to be obtained from the Public Lands Trust Board of Trustees.	Key piece of legislation relevant to the dredging of lagoons and extraction of aggregates.
Chapter 1 of Title 43 of the Pohnpei State Code - Land Acquisition	This chapter lays out the provides rules for the acquisition of real property in projects and programs implemented by the state and local government, and state agencies.	No specific coverage of mineral / aggregate extraction.
Chapter 3 of Title 26 of the Pohnpei State Code - Soil and Water Conservation Act of 1992[81]	The purpose of this Act is to promote soil and water conservation by preventing erosion in order to conserve and improve the use of the land and water resources.	No specific coverage of mineral / aggregate extraction though this Act would clearly be relevant if these activities led to erosion.
Chapter 1 of Title 42 of the Pohnpei State Code -Public Lands Act of 1987[82]	This act provides for the management and administration of public lands in Pohnpei, including establishing a division within the Department of Land and Natural Resources with oversight of these matters.	No specific coverage of mineral / aggregate extraction.
Chapter 1 of Title 27 of the Pohnpei State Code - Pohnpei Environmental Protection Act of 1992[83]	Establishes the Pohnpei EPA, including outlining its power and duties. Also declares the state's environmental policy in relation to environmental protection and sustainable development.	Activities falling under the remit of the EPA include earthmoving activities and mining and dredging and the removal of mined and dredged materials from Public Trust Lands, which would include aggregate extraction.
Chapter 2 of Title 6 of the Pohnpei State Code - Planning[84]	Provides for development planning in Pohnpei. Requires local governments to develop comprehensive plans for development of their jurisdictions, taking into considerations such	No specific coverage of mineral / aggregate extraction but does provide for the conservation of the natural resources and protection of the environment of the local jurisdiction.

[79] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC185804. Accessed 26/10/2023.

[80] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079813. Accessed 31/10/2023.

[81] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079335. Accessed 31/10/2023.

[82] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079551. Accessed 26/10/2023.

[83] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079408. Accessed 26/10/2023.

[84] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079227. Accessed 26/10/2023.

Act / policy	Description	Relevance to aggregates sector
	things as conservation of natural resources and environmental protection.	
Chapter 1 of Title 41 of the Pohnpei State - Pohnpei Land Use Planning and Zoning Act of 1993.[85]	The act deals with land use planning in Pohnpei, which has the objectives of promoting responsible and balanced development. It applies to both public and private land with a focus on the conservation, protection and development of natural resources.	Provides for the conservation, development, use and protection of minerals, marine resources, and other natural resources. Dredging of sand and coral are identified as specific "conservation elements".
Chapter 2 of Title 42 of the Pohnpei State Code -Lease and Use Agreements[86]	This Chapter concerns use and lease of public land, which is regulated by the Public Lands Trust Board of Trustees. Land may be leased to foreign companies but only for the time they are doing business in Pohnpei. The Chapter also provides rights to minerals and exhaustible resources to the Public Lands Trust for the public interest.	Legislation deals with rights to minerals, which are held by the Public Lands Trust. The Board of the trust is authorized with leasing and use of public lands though no mention of how mineral royalties etc. will be managed.
	KOSRAE	
Chapter 1 of Title 19 of the Kosrae State Code (Marine Resources) - General Provisions[87]; and Chapter 4 of Title 19 of the Kosrae State Code (Marine Resources) - Prohibited Acts.[88]	This Chapter among other things defines the sovereign rights of the Kosrae State in relation to conserving, managing, and developing living and non-living resources within Kosrae's fishery waters; charges the Department of Agriculture, Land and Fisheries with the powers to administer, manage etc. fishery waters; grants regulation-making powers to the Director of the Department; and requires a person wishing to carry out an activity that may affect the quality of fishery waters to inform the Director who may require an EIA. 'Prohibited acts' include damaging a reef by "dredging, mining, removing coral or rocks, running a vessel aground or by any other means".	Relevant to dredging and sand mining activities in coastal waters, particularly Chapter 4, which prohibits damage to coral reefs caused by these activities.
Resource Management Regulations[89]	These regulations establish EIA process in order to help the general public and government officials make decisions that are informed by an understanding of the environmental consequences of their decisions, and to take actions to protect, restore, and enhance the environment.	Among other things, the regulations directly deal with aggregate extraction activities, including dredging, sand mining and quarrying.

Source: FAOLEX database and other reports

3.2.5 The Institutional and operating context

FSM's institutional and operating context is somewhat complex given that many of the government's powers are delegated to the states which, in turn, have their own government agencies and regulations. This section provides a brief summary of relevant key national government ministries,

[85] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079501. Accessed 26/10/2023.

[86] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079804. Accessed 26/10/2023.

[87] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079147. Accessed 26/10/2023.

[88] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC079151. Accessed 26/10/2023.

[89] Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC121182. Accessed 26/10/2023.

before discussing government agencies at the state level, focusing on those with a clear role in regulating the quarrying, dredging and mining sectors.

Key national government departments

Department of Transportation, Communications, and Infrastructure

The Department of Transportation, Communications, and Infrastructure is the national government department that coordinates and manages all interstate and international sea and air transportation, regulates the radio communication spectrum, and implements, coordinates, and manages all capital projects funded by the FSM Congress.[90] It is responsible for implementation of the National Infrastructure Development Plan. Each state also has its own specific version of this plan.

Department of Resources and Development

This department is responsible for managing the development of FSM's economy and use of the country's natural resources in a sustainable manner and in line with the provisions of the nation's Strategic Development Plan in the areas of economic development, resource management and conservation. The department is also responsible for assisting and coordinating with FSM's four states to develop their economies, with a focus on the four priority sectors of agriculture, energy, fisheries, and tourism.[91]

This department has three divisions tasked with carrying out its mandate. They include the Division of Energy, Division of Resource Management and Development, and Division of Trade and Investment.

Department of Environment, Climate Change and Emergency Management

The Department of Environment, Climate Change and Emergency Management's strategic goal is "to monitor, guide, supervise and provide policy directions, logistics and administrative support to the Divisions and liaise with other offices and agencies of the government."[92] The department deals with all matters relating to emergencies, the environment, including climate change, and sustainable development. It is also tasked with facilitating support to the four states to implement FSM's Strategic Development Plan. The department is currently comprised of three divisions: the Emergency Management Division, Climate Change Division, and Environment Division.[93]

[90] Department of Transportation, Communications, and Infrastructure. https://tci.gov.fm/infrastructure.html. Accessed 26/10/2023.

[91] Devex. https://www.devex.com/organizations/department-of-resources-and-development-micronesia-127589. Accessed 30/12/2023.

[92] Devex. https://www.devex.com/organizations/department-of-environment-climate-change-and-emergency-management-decem-146256. Accessed 26/10/2023.

[93] Pacific Community and Pacific Islands Forum (2019). *Federated States of Micronesia Climate Change and Disaster Risk Finance Assessment*. https://www.forumsec.org/wp-content/uploads/2019/09/Federated-States-of-Micronesia-Climate-Change-and-Disaster-Risk-Finance-Assessment.pdf. Accessed 30/12/2023.

Key state government agencies

Yap EPA

Public information on Yap's EPA is limited; however, it is responsible for overseeing Yap's earthmoving regulations, and hence all activities related to dredging, mining, and lagoon land reclamation.

Chuuk EPA

Similarly, public information on Yap's EPA is limited. The only public information on its roles and responsibilities is in the legislation, which states that the Yap EPA is responsible for overseeing the state's environmental impact assessment regulations, which deal with, among other things, "resource exploitation".

Pohnpei EPA

The main functions of the Agency are undertaken by eight Divisions: Management, Pollution Control (Permitting System) , Laboratory & Safe Drinking Water, Quarantine, Establishment, Climate Change and Community Improvement, and Environmental Education.[94] Outputs of all divisions are aimed at ensuring wise use and protection of Pohnpei's natural resources. The main function of the EPA board is to evaluate and monitor development projects proposed through the Agency's development project permitting process. The board also has the authority to cease development projects not complying with permit conditions as issued according to the laws and regulations.

The EPA has responsibility for enforcing key regulations relevant to the aggregates sector, including the earthmoving regulations and environmental impact assessment regulations (see previous section) .

Kosrae Island Resource Management Authority

The Kosrae Island Resource Management Authority operates as a semi-autonomous agency within the State Government of Kosrae and has five units (historic, marine, terrestrial, education, and permitting) .[95] These units monitor and inform policy for the protection of the island's resources.

Pohnpei Department of Land and Natural Resources

The Department has overall legal mandate to administer and manage the State land system and land distribution, through and in collaboration with bodies such as the Board of Trustees on Public Lands, the Board of Land Survey and Examiners, Soil and Water Conservation Council, and others.[96] Its mandate encompasses Pohnpei's land, ocean, historic sites, parks, watershed areas, and public lands, and includes matters such as lands use and zoning, preservation of flora and fauna, coastal resource management, and marine natural resources within the state's "12 miles zone". It is also responsible for the management and prevention of environmental degradation of watersheds and coastal resources.

The Department's Divisions include the Division of Public Lands, Division of Survey and Mapping, and Division of Forestry and Marine Conservation. The Division of Public Lands is tasked with the regulation of dredging and sand mining and issuance of permits by the Board of Trustees of Public

[94] Pohnpei Environmental Protection Agency. https://pohnpeistate.gov.fm/agency_protect.html. Accessed 30/12/2023.

[95] Kosrae Island Resource Management Authority. https://irma.kosraestate.gov.fm/archives/. Accessed 30/12/2023.

[96] Department of Land and Natural Resources. https://pohnpeistate.gov.fm/dept._land.html. Accessed 30/12/2023.

Lands. Meanwhile, the Division of Marine Conservation is responsible for the management and administration of 11 designated marine protected areas and other reserves and watershed areas, including enforcing all state laws and rules.

3.3 Fiji

A comprehensive country profile of aggregates availability and extraction was completed by the authors for Fiji as part of the 2018 Baseline Assessment of Development Minerals in Fiji, which was undertaken for the ACP-EU Development Minerals Programme.[97] The baseline assessment provided a detailed overview of the geography and geology of Fiji, documented licensed and unlicensed aggregate reserves and extraction activities, the legal and policy framework, and other topics—much of which remains relevant and accurate some 5 years later. The current country profile for Fiji therefore draws on this baseline but updates information based on new developments and knowledge of the aggregates and infrastructure sectors since that time. Since the level of detail and analysis on such things as Fiji's geology was extensive in the baseline, the reader is encouraged to refer to relevant sections where needed.

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Fiji	**Very high** As one of the largest economies in the Pacific, Fiji has a very large infrastructure project pipeline, in the order of $2.7 billion. PRIF members have identified projects budgeted at $682.5 million.	- Volcanic rock - Limestone - River gravel and sand - Coastal sand / gravel (no current extraction) - Lagoon sand / gravel (no current extraction)	**Medium-High** 2020–2022 imports: ~388.9 tons 2020–2022 exports: 45,005 tons Significant aggregate resources of all types (limestone, basalt/ volcanics river sand and gravel) plus numerous operational quarries and river extraction sites. Fiji is an important exporter to the region and has reasonable self-sufficiency. The main challenge is sourcing these aggregates responsibly, particularly from Fiji's rivers. In addition, recent discussions with the MRD indicate that despite being an exporter, Fiji is currently facing challenges meeting domestic aggregates demand.

3.3.1 Geography and geology

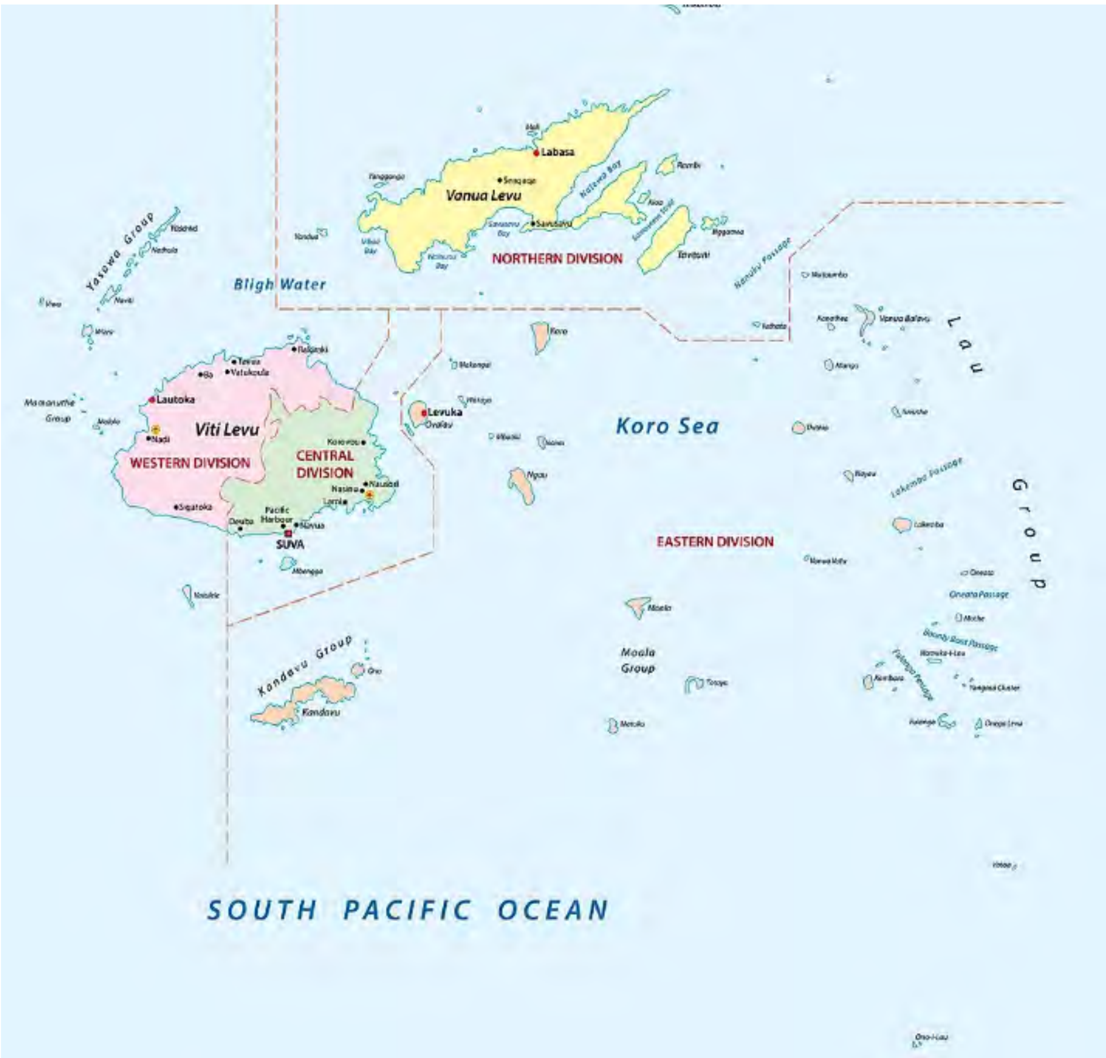
Fiji is an archipelago located in the South Pacific consisting of 110 inhabited and 222 uninhabited islands, as well as numerous small islets. The archipelago covers a large area of ocean between 15° and 18° south of the equator, and 175° east and 177° west. Fiji's ocean area covers around 1,260,000 km^2, while the land area is only 18,272 km^2. As with all PICs, this large "ocean to land area" ratio presents Fiji with several developmental challenges, particularly in terms of communications and transport, supply chains and economic activity, much of which is centered on the two largest islands, Viti Levu and Vanua Levu. Furthermore, 87% of Fiji's total population of 937,353 people live on the

[97] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme.

two largest islands, Viti Levu and Vanua Levu, which have populations of around 600,000 and 135,000 people respectively.[98] Suva, the capital city, has the largest population with 87,000 people but this increases to 175,000 if surrounding suburbs are included. The Eastern Division, encompassing Kadavu and the Lau Group, is the least populated part of the country, with only around 4% of the population.

Administratively, Fiji is divided into four divisions (Figure 27) . The Western Division covers the western half of Viti Levu and surrounding islands including those of the Mamanuca and Yasawa groups. The Central Division covers the eastern half of Viti Levu and nearby islands. Meanwhile, the Northern Division comprises Fiji's second large island, Vanua Levu, as well as Taveuni and other islands, while the Eastern Division comprises Kadavu, the Lau Group and numerous islands in this part of the country.

Figure 27: Map of Fiji



Source: worldatlas.com

The Fiji Islands are the exposed parts of a remnant volcanic arc system of late Eocene age located within the active boundaries of the Pacific and Indo-Australian plates, where the Pacific Plate is

[98] World Population Review. https://worldpopulationreview.com/countries/fiji-population. See also https://worldpopulationreview.com/countries/cities/fiji

subducting in a westwards direction under the Indo-Australian plate.[99] This has produced a complex geological history beginning with the eruption of pillow lavas, coarse volcanoclastics, with interlayered dacitic volcanoclastic rocks and limestone. Volcanic eruptions in the Early Oligocene created arc-like basalts with interlayered limestones. Most of the oldest rocks in Fiji are found in western Viti Levu.

The subsequent geological development of the Fiji Islands and associated rocks and sediment formations are summarized in Table 9 and the map in Figure 28. For a detailed discussion of this geological development readers should refer to the relevant sections of the Baseline Assessment of Development Minerals in Fiji (2018) .[100]

Table 9: Geological Summary of Fiji

Unit	Approximate Age	Description
Yavuna Group	Late Eocene to Early Oligocene (37.8 to 23.0 Ma)	The oldest known rocks in Fiji and represent part of a volcanic arc (Yavuna Arc). The group consists of basaltic pillow lavas, dacite, a tonalite stock, and shallow-water limestone.
Wainimala Group	Late Oligocene to Middle Miocene (28.1 to 11.6 Ma)	The group is broadly defined as a deformed volcanic-sedimentary group showing low grade metamorphism related to younger plutonic intrusions. The volcanic rocks of the Wainimala group are both pyroclastic and flow deposits of various different compositions, including; basalt, andesite, trachyte and rhyolite. The sedimentary rocks of the Wainimala Group consist of limestone, sandstone, and mudstone. Phyllite, schist and gneiss are also present due to metamorphism associated with the intrusion of the Tholo Plutonic Suite.
Colo Plutonic Suite	Middle and Late Miocene (11.6 to 5.3 Ma)	These intrusive rocks occur in an elongate belt from the southwest to the east of Viti Levu. The suite predominantly consists of gabbro and tonalite, with occasional granodiorite and diorite.
Tuva Group	Middle to Late Miocene (11.6 to 5.3 Ma)	This group of rocks is strongly deformed in places; and predominantly consist of breccia, conglomerate, sandstone, with minor mudstone.
Macuadrove Super-Group	Late Miocene onwards (7.2 Ma onwards)	This group of rocks is predominantly submarine and only occasionally subaerial. Volcanic rock types include; basalt, andesite, dacite, rhyolite. Sedimentary sandstones and marls are also present.
Various sedimentary rocks	Late Miocene to Holocene (7.2 Ma onwards)	The sedimentary rocks from the Late Miocene onwards consist of various grain sizes corresponding to paleo sea levels and tectonic events. Rock types include: marl, sandstone, limestone, conglomerate, greywacke, and reworked volcanoclastics.
Calc-alkaline Volcanic Rocks	Late Miocene to Early Pliocene (7.2 to 3.6 Ma)	Predominantly volcanic rocks consisting of andesite, dacite and basalt, with occasional intrusive plugs at the remnant volcanic centers, including gabbro, microsyenodiorite, tonalite, granodiorite
Shoshonitic Volcanic Rocks	Early Pliocene (3.6 to 2.6 Ma)	Predominantly basalt with associated monzonite intrusives.
Alkali-basaltic Volcanic Rocks	Middle Pliocene onwards 3.6 Ma onwards)	Basaltic rocks associated with an extensional tectonic setting.
Coral reefs and associated deposits	Quaternary to present Day (2.6 to 0 Ma)	Emerged reefs, present day reefs, lagoon, and beach deposits

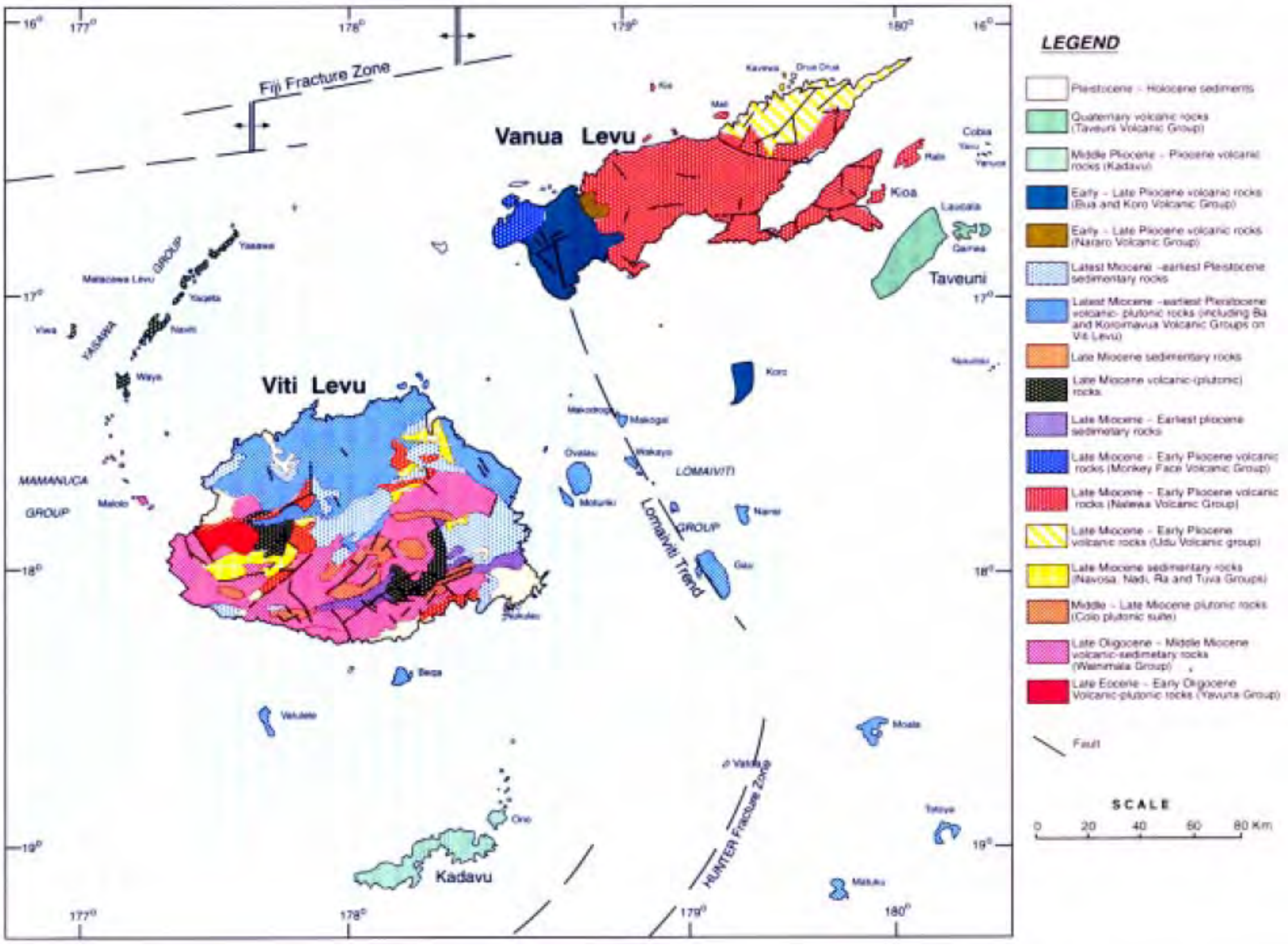
[99] Fiji Mineral Resources Department (n.d.). *Plate Tectonic History of Fiji*. Brochure.

[100] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme. https://www.undp.org/pacific/publications/baseline-assessment-development-minerals-fiji.

Unit	Approximate Age	Description
Alluvium	Holocene to present day (11,700 to O kyr)	Unconsolidated sediments (sand, silt and gravel) deposited by rivers

Source: Smith et al. 2018

Figure 28: Geological Map of Fiji



Source: Fiji Mineral Resources Department, Geology and Mineralisation Information Sheet. https://www.mrd.gov.fj/images/Geological_Survey/Fiji_Geology__Minerals.pdf

3.3.2 Summary of aggregate extraction sites and known resources

The 2018 Baseline Assessment of Development Minerals did a country-wide assessment of all aggregates and other Development Minerals in Fiji. Data on regulated sites were obtained from the MRD and from other bodies who also hold datasets, including the Department of Lands (DoL) and the iTaukei Land Trust Board (TLTB) , which administers leases on traditional lands, including quarries and other activities. The baseline team observed that there were no official records on unregulated aggregate sites in Fiji, and this remains the case today. To overcome this limitation, the study team used Google Earth imagery and field observation to identify unregulated sites.

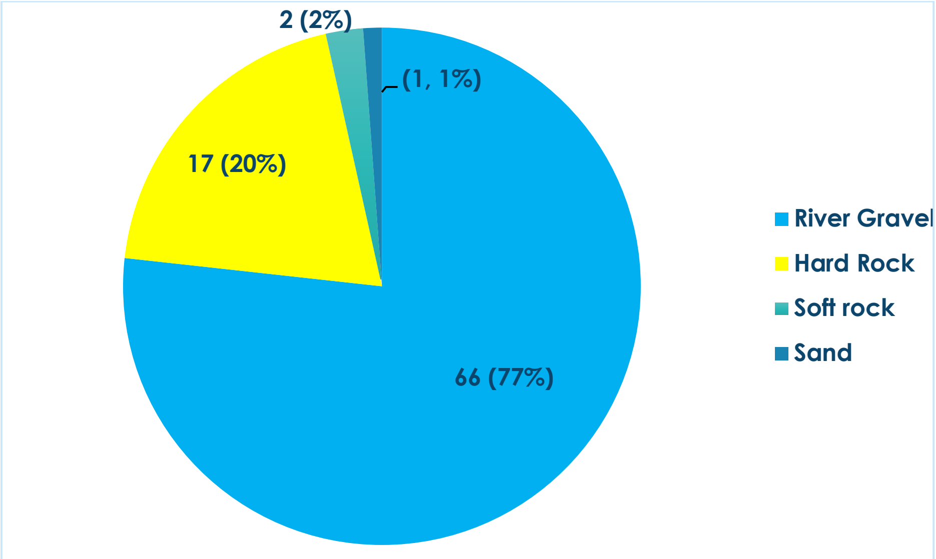
For the purposes of this report, we have updated the information on the regulated sites using 2024 data sourced from the MRD. However, we have relied on data for unregulated sites from the baseline.

It should also be cautioned that identification of unregulated sites is challenging and even the baseline team was unable to identify all sites despite extended periods of time in the field.

Regulated aggregate extraction sites

The 2018 Baseline Assessment focused on development minerals, of which aggregates were the major, but not only, minerals surveyed. For instance, clay was also included in the survey in the soft rock quarry category, while hard rock quarries in Fiji are almost exclusively rock of an igneous variety. Nevertheless, as shown in Figure 29 below, the majority of the development minerals extraction sites identified were river extraction sites for gravel and sand (77%) , followed by hard rock quarries (17%) , with soft rock quarries and sand quarries representing only a very small portion of all quarries (2% and 1% respectively) . Excluding soft rock quarries there were a total of 84 regulated aggregate extraction sites in Fiji in 2018.

Figure 29: Breakdown of Regulated Extraction Sites, 2018

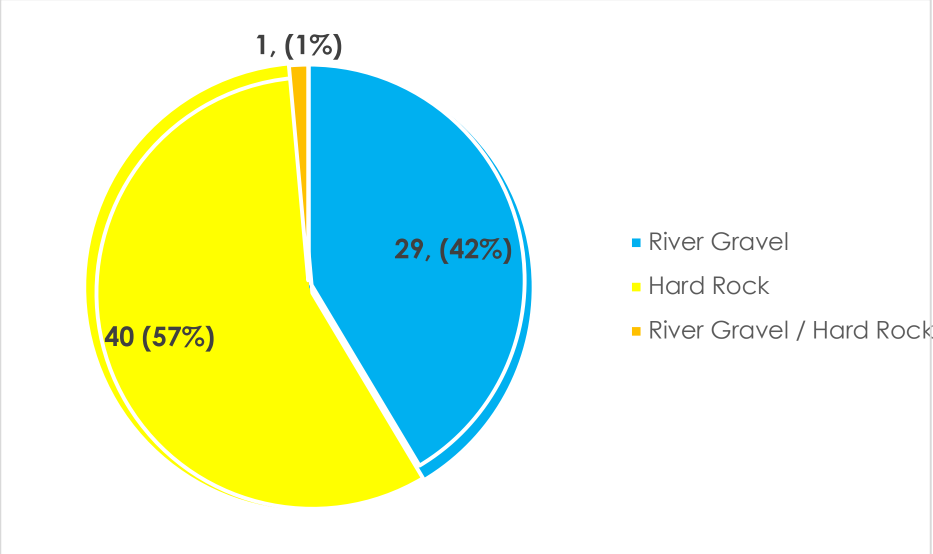


Source: Smith et al. 2018

The most recent data obtained from the MRD in 2024 indicate that there are currently 70 regulated sites across three of Fiji's four administrative divisions, 57% of which are hard rock quarries, 42% river extraction sites (gravel and sand) , and 1% are combined river gravel / hard rock quarries (Figure 30). However, 27 of these sites are listed as "Not in Operation" in the MRD's database.

River gravel extraction site in Fiji. Photos show: a) before mining; b) during mining; and post-mining sites (photo credit: Daniel Franks, 2022).

Figure 30: Breakdown of Regulated Extraction Sites, 2024



Source: Fiji Mineral Resources Department data, 2024

From a geographic perspective, the Western Division has most sites (25, ~36%) followed by the Northern Division (24, ~34%) and Central Northern Division (20, 29%) . The Eastern Division has only 1 site, which is likely due to its remoteness, low population and limited construction activities. In terms of the aggregate type, the Northern Division has the most hard rock quarries (16) and the Western Division has the most river extraction sites (14) (Table 10) . It is interesting to note that the number of river gravel extraction sites has declined as a percentage of all quarries compared with 2018, with 42% of all quarries being river gravel sites 2024 versus 77% in 2023. It is also noteworthy that there appears to be only one operational limestone quarry in Fiji at the time of writing, though it apparently contains very large reserves.

Table 10 Distribution of Quarries by Type and Administrative Division

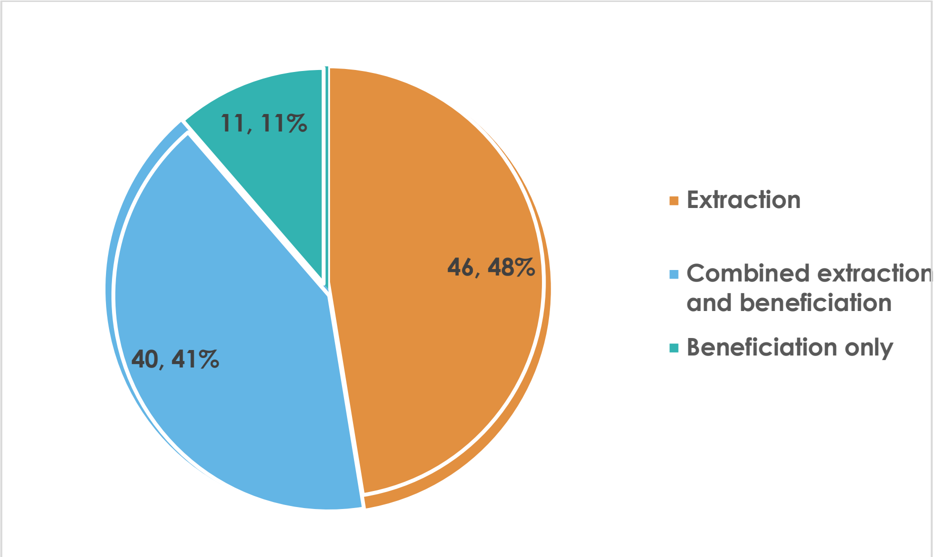
	River Gravel	Hard Rock	River Gravel / Hard Rock	Total
Central Division	8	12	0	**20**
Northern Division	7	16	1	**24**
Western Division	14	11	0	**25**
Eastern Division	0	1	0	**1**
Total	**29**	**40**	**1**	**70**

Source: Mineral Resources Department, 2023 data

Beneficiation activities

Beneficiation of aggregate materials in regulated sites typically involves washing, crushing, and screening of materials. In some cases, this is done at site, while in others material is transported to a separate beneficiation site. The 2018 Baseline Assessment found that around 41% of regulated operations had combined extraction and (onsite) beneficiation, while 48% had extraction only. The remaining 11% involved beneficiation only (Figure 31) .

Figure 31: Beneficiation in Regulated Development Minerals Operations



Source: Smith et al. 2018

Figure 32: Hard Rock Quarry, Fiji

Photo credit: Paul Rogers, UQ 2023

Unregulated sites

For the current report, we have relied on the 2018 Baseline for information about unregulated quarry sites in Fiji, given there is no single source of data and identifying sites would require significant time in the field and other resources not available to the consultants for this project. The baseline identified 30 sites in 2018, though cautioned that there were likely more that had not been identified. Of the 30 sites, 27 involved unregulated river gravel extraction. One unregulated site was a hard rock quarry and two were soft rock quarries, though it is not clear if these were for aggregates (e.g., limestone) or other minerals (e.g., clay).

The unregulated river gravel sites were typically small operations involving 2–3 workers, an excavator and 1–2 trucks. The hard and soft rock quarries appear to be slightly larger operations, with one site having five personal, three excavators, and two trucks. Discussions with personnel on site at one unregulated soft rock quarry revealed that the operator had been issued a lease to conduct agricultural activities but had instead commenced quarrying, without necessary approvals such as EIA. This is likely a phenomenon repeated in other parts of Viti Levu and perhaps across the country. The environmental implications of this are unlikely to be positive without compliance with environmental impact measures in place.

Offshore sand dredging operations

Other than in Ba in the northern part of Viti Levu, there are no reports of any offshore sand dredging operations at the present time in Vitu Levu though the situation in other parts of the country is unknown.

3.3.3 Aggregates required for infrastructure development in Fiji

National Infrastructure Investment Plan

Fiji has recently released its National Infrastructure Investment Plan (NIIP).[101] The NIIP is a guide to assessing infrastructure investment over the next 5–10 years and was produced with the support of PRIF. It examines the infrastructure needs of all sectors, drawing on the National Development Plan objectives, and sectoral and institutional level plans. It provides a list of priority infrastructure projects that will require investment over the coming years. It also assesses the likely economic viability of projects and the capacity of government to fund and deliver them. The NIIP identifies 31 priority projects covering nine sectors with an investment value of F$6.139 billion ($2.762 billion).[102] Whether all these projects will go ahead is not known. There is also a significant ongoing pipeline of projects already in development.

Parallel to this, PRIF has also released a list of 11 key infrastructure projects. As shown in Table 11, these projects will require an investment of $682.5 million and cover four sectors, namely transport, energy, water and sanitation, and urban development.[103] If these projects are to go ahead, they will require a very large quantity of aggregates over the next few years. For most projects, budget decisions will be made over the next 2 years.

[101] Fiji National Infrastructure Investment Plan 2023–2034. https://theprif.org/sites/default/files/documents/Fiji%20National%20Infrastructure%20Investment%20Plan%202023_final.pdf. Accessed 05/09/2023

[102] Based on a 2023 average annual exchange rate of F$1= $0.45.

[103] Not including investment in two of these projects, which have not yet been reported.

Table 11: Infrastructure Projects Identified by PRIF Members for Fiji and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Bridge Replacement Project	60	High	Relatively large project based on budget with significant quantities of aggregate needed for concrete support structures and surfacing.
Transport	The Project for Improvement of Safety Facilities at Major Airports	11	TBC	Assessment of aggregate demand pending further project information
Transport	Tourism Development Program in Vanua Levu (including airports)	40	Medium-high	Final assessment of aggregate demand pending further project information
Energy	Fiji Hydropower Development – Phase 3 including Qaliwana Hydropower Extension - Lower Ba	TBC	High-very high	Hydropower projects use vast amounts of aggregates and cement to produce concrete.
Energy	Upgrading three existing outer island mini-grids to include additional solar and storage	3	Low	Relatively low budget and apparent focus on technology, rather than structures means aggregate and cement demand will likely be low.
Energy	Climate Investment Funds Renewable Energy Integration Program	TBC	TBC	Final assessment of aggregate demand pending further project information, but project may not include use of building materials
Water and Sanitation	Nadi Flood Alleviation Project – Component B (w/JICA and DFAT)	100	Very high	Final assessment of aggregate demand pending further project information but if focus is on dams, river stabilization etc., demand could be high, particularly given size of budget
Water and sanitation	Urban Water Supply and Wastewater Management Program, Tranche 2 (w/EIB)	155.3	Very high	Final assessment of aggregate demand pending further project information but if focus is on building / expanding reservoirs, pumping stations etc. demand could be very high, particularly given size of budget
Water and sanitation	Nadi Flood Alleviation	205.2	Very high	Likely to involve construction of water retention damns, which will require large quantities of cement and aggregate for concrete.
Water & Sanitation/ Urban Development	Nadi Flood Alleviation Project (w/ADB & DFAT)	33	High	As above
Water and sanitation	Urban Water Supply and Waste Water Management Investment Program (co-financed with ADB)	75	High	Likely to involve construction of a pumping station, water treatment plant, clear water reservoir and a pipeline. This will require large quantities of concrete / aggregate

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Total ($)		**682.5 million**		

ADB = Asian Development Bank, DFAT = Australia Department of Foreign Affairs and Trade, EIB = European Investment Bank, JICA = Japan International Cooperation Agency, PRIF=Pacific Regional Infrastructure Facility, TBC = to be calculated.

Source: PRIF 2023; relevant project reports where available

3.3.4 Overview of the legal and policy framework

Land and resource ownership

There are three main types of land ownership in Fiji. Customary land comprises around 92% of all land and is governed by the iTaukei Land Act and the iTaukei Land Trust Act (1940), with several later decrees. The rest is freehold land (around 8% of all land) and state land (2%). Indigenous Fijians (*iTaukei*) own land in collective groupings / units based on custom and tradition.[104] For instance, land can be owned by heads of tribes, members of a tribe (including family units), their descendants and so on. A record of the members of these grouping is kept by various iTaukei Land and Fisheries Commissions (ILFC), as provided for under the iTaukei Land Act.

The land rights of members of these units are similar, but not the same as owners of freehold land. Members can occupy land, use it for their livelihoods, lease it to others and determine the terms and conditions of leases as laid out under the Land Transfer Act. However, ownership of land is in essence collective in nature and even if members are occupying land, they may not dispose of or transfer these rights to another person. “Native title” comes from historical and ancestral possession and, similar to freehold land, has always been seen as land tenure, unlike in other common law jurisdictions like Australia and New Zealand.

State land is governed by the State Lands Act and gives the state authority over the beds of rivers and streams, the foreshore, seabed, and reefs.[105] The state also owns all minerals on land and under water on both customary and freehold land, but the Constitution requires that landowners are entitled to the payment of a fair share of royalties or other money received by the state in relation to the grant of mineral extraction rights on either land or underwater (Sec. 30).

Colonial-era influences continue to shape land affairs in independent Fiji. These include common law restrictions preventing state expropriation of land, something that derives from the Magna Carta of 1215 and was carried through to Fiji’s unwritten constitution when Britain declared sovereignty in 1874. However, as with previous constitutions during the independence era, the fourth and latest version of the Republic of Fiji’s Constitution (2013) affirms restrictions on state expropriation but does allow expropriation for “public purposes” on payment of fair compensation.

Constitution of the Republic of Fiji, 2013

The relevant section of Fiji’s Constitution that deals with minerals is section 30. Subsection (1) declares that the State owns all minerals, whether on customary or freehold land, but that landowners are entitled to a “fair share of royalties or other money paid to the State”:

> *All minerals in or under the land or water are owned by the State, provided however, that the owners of any particular land (whether customary or freehold), or of any or of any particular registered customary fishing rights shall be entitled to receive a fair share of royalties or other money paid to the State*

[104] iTaukei Land Trust Board. https://www.tltb.com.fj/Landowners/Ownership-Rights. Accessed 12/09/23.

[105] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme.

in respect of the grant by the State of rights to extract minerals from that land or the seabed in the area of those fishing rights.

Furthermore, subsection (2) states that:

A written law may determine the framework for calculating fair shares under subsection (1), taking into account all relevant factors…

These factors may include such things as the benefit the owners might receive due to mineral exploration and extraction, the risk of environmental damage, legal obligations of the state to contribute to a fund to meet the costs of preventing, repairing, or compensating for environmental damage, and other factors.

The Constitution does not provide a definition of minerals, unlike the State Lands Act and Minerals Act discussed below.

State Lands Act (last amended 2022)

Originally known as the Crown Land Act of 1945, this Act was renamed the State Lands Act following an amendment in 1975. Its provisions deal with the control, administration, and disposal of state land. Section 7 Act deals with minerals, stating that *"a grant under this Act shall not confer any right to any previous metals, coals or minerals of any description…."* Like both the Constitution and Minerals Act, it excludes sand, gravel, and rock from the definition of minerals, meaning there is no legislative requirement to get permission to extract these minerals. However, there remains uncertainty about the need to obtain licenses to extract from rivers and streams that run through freehold and customary land, which is managed by TLTB.[106] There is also uncertainty about the enforcement of royalty payment obligations and payment of taxes.

Rivers and Streams Act 1985

This act deals with the public's rights in relation to Fiji's rivers and streams. Section 2 declares that all waters that native people are, or have been, accustomed to navigating or using belong to the state, as does the soil beneath them. They are, however, "perpetually open to the public for the enjoyment of all rights incident" to them (Sec 2). This, in effect gives the Department of Lands jurisdiction to issue licenses for sand and gravel extraction from the river and stream beds.[107]

Quarries Act (1939 (amended 1963 and 1969)

This act deals with the location and extraction of all "rock, earth, clay, sand, soil, gravel, limestone, or such other common mineral substances", as defined in Section 2 of the Mining Act. However, it is problematic for several reasons, including that it only deals with operations that involve use of explosives or materials that are destined for rock crushing and treatment plant. Only operations with these characteristics are defined as "quarries". Furthermore, the definition of minerals is not consistent with the definition in the Mining Act, which excludes things like sand, gravel, and stone (see below).

[106] Ibid.

[107] Ibid.

Mining Act 1966 (last amended 2005

The Mining Act affirms that all minerals are owned by the state or "Crown" (Sec. 3). Minerals are defined to include a wide range of minerals, from metalliferous minerals and gemstones to petroleum and "earthy materials" like gypsum and salt. However, aggregates such as gravel, sand and stone are excluded, as are other development minerals like clay (Sec. 3 (f)). One implication of this is that if sand and gravel are extracted from freehold land, the mineral licensing framework does not need to be followed, unless materials are extracted from a stream bed or it is to be delivered to a crusher. If the latter, the operation would be considered a quarry and would therefore need a license from the MRD in the Ministry of Lands and Mineral Resources.

It is also imported to note that while the Environmental Management Act of 2005 applies to mining and extraction from riverbeds, it does not mention sand and gravel. This means that there is uncertainty as to whether the EIA provisions of the act apply to extraction of these minerals.

Table 12 summarizes the role of different government institutions in licensing quarry and river gravel operations in Fiji. Additional information is provided in Table 14.

Table 12: Role in Licensing Quarry and River Gravel Operations

Institution	Role in licensing
Department of Lands	• Issuing licenses for sand and gravel extraction on native, freehold, and state land under the Rivers and Streams Act. Its jurisdiction is limited to: o Rivers and stream beds • Issuing licenses for quarries under the Quarries Act but only in circumstances where material is destined for a rock crusher or treatment plant.
Mineral Resources Department	• Issuing licenses for sand and gravel extraction for the specific purpose of delivering to a crusher (i.e., for quarry operations)
TLTB	• Issuing licenses for sand and gravel extraction in rivers and streams passing through iTaukei land but only on land lying above the high-water mark (i.e., not river and stream beds)

TLTB = iTaukei Land Trust Board.
Source: Smith et al. 2018

Environmental Management Act 2005

This act makes provides the legislative architecture for the protection of the Fiji's environment. Among other things, the act defines the principles and purposes of environmental protection; establishes a National Environment Council; outlines the functions and powers of the Department of Environment; describes rules and processes for environmental impact assessment, as well as waste management control and pollution prevention; and defines environmental offences.

Town Planning Act 1966 (amendments 1995 and 1997

The Town Planning Act does not deal with the extraction of aggregates or other development minerals but does affirm that a person engaged in quarrying or mining under a neighboring title at the time of a new planning order is considered to be engaged in an "existing use" and shall therefore be allowed to continue operations (Sec. 2).

Roads Act

The Roads Act gives the state authority to extract materials for the construction or repair of roads, but with compensation only for the damage caused, not for the actual value of the material.

Policies

There are several policies that have both direct and indirect implications for the extraction and supply of aggregate resources in Fiji. As discussed below, they include, but are not limited to, a new policy to phase out river gravel extraction, as well as EIA regulations that have implications for both quarry and river extraction operations. There is also a new draft Guideline for River Gravel and Sand Extraction. These and other key policies are discussed below:

5-Year and 20-Year National Development Plan

Fiji's National Development Plan is comprised of a 20-year plan and a 5-year plan. The latest 5-year development plan is for 2017–2021, but, as of September 2023, it does not appear to have been updated. This plan covers numerous sectors and topics, ranging from water and sanitation to mining and financial services.

Chapter 3.2.15 of the National Development Plan outlines Fiji's approach to developing a sustainable mining sector, in which "Government will ensure sustainable mining practices and ecological balance together with equitable sharing of revenue amongst investors, landowners and the State". The Plan states that there will be revisions to the Mining Act, policies, and institutional framework for mining and quarrying, including monitoring and evaluation of operations and oversight of OHS and environmental safeguards. So far, the Mining Act has not been amended to incorporate these changes. There is also a commitment to strengthening the monitoring of the environmental impact of mining and quarrying and broadening the responsibilities of the Ministry of Lands and Mineral Resources to include assessment and monitoring of river-gravel extraction and fine-sand dredging.

Environmental impact assessment

Fiji's Environmental Impact Assessment process regulations (2007) are provided for under Fiji's Environmental Management Act. Without EIA approval, mineral extraction is prohibited. The Department of Environment within the Ministry of Waterways and Environment (MoWE) plays the key role in governing the EIA process. The EIA process entails five main steps, as summarized in Table 13 below.

Table 13: Fiji's EIA process

Step	Process
Step 1 - Screening	Screening is undertaken by the Department of Environment to determine whether an EIA is required for the proposed development (e.g., a mine/ quarry).
Step 2 – Scoping	If an EIA is necessary, the next step is to determine the scope of an EIA study (Step 3) which includes identifying potential environmental impacts that might need further investigation. It also involves establishing a term of reference (TOR) for the EIA study. Scoping must be completed within 30 days from the date the proposal is received. The TOR must be approved by the Director Environment.

Step 3 – Study and report	The EIA study involves collecting environmental baseline data and assessing environmental impacts. The study also includes producing a comprehensive EIA report of the potential impacts of the proposal, and outlining measures required to mitigate the impacts. The report is to be produced by a registered environmental consultant. It must include public consultations in the area of the proposed development.
Step 4 - Review	The report is then reviewed be a registered consultant (but not by the consultant who undertook the study). Alternatively, it can be reviewed by committee as directed by the Department of the Environment, comprising up to 10 members from industry, government, local communities etc.
Step 5 - Decision	The Department of the Environment must decide within 35 days of the report submission. It may a) approve the proposal; b) recommend any additional study on the proposal; or c) approve the proposal, with or without conditions.

EIA = environmental impact assessment.

Source: MoWE website; Smith et al., 2018

Draft guideline for river gravel and sand extraction

The MRD has developed a draft River Gravel and Sand Extraction Guideline for Fiji which is now sitting with the Attorney General for formal approval.[108] The guideline aims to improve monitoring and long-term sustainability of the sector while preserving the environmental integrity of these natural resources and the environments they are extracted from. The Guideline covers several major topics, including: the environmental impacts on riverine environments from river gravel and sand extraction; the statutory and administrative framework for river extraction management; river gravel and sand management; principals for mitigating adverse environmental effects of extraction on riverbeds; and operational guidelines for gravel and sand extraction. A shorter, River Gravel and Sand Extraction Management Guideline has also been drafted. This guideline will presumably be released in the coming months.

3.3.5 The institutional and operating context

A total of six ministries and ten government departments / services and other institutions are involved in the governance of aggregate operations, in Fiji. The roles and responsibilities of each are summarized in Table 14.

Table 14: Roles and Responsibilities of Government and Other Institutions in Governance of the Aggregates Sector

Ministry / Institution	Roles and responsibilities
Ministry of Waterways and the Environment	**Department of Waterways**[109] The Department of Waterways is responsible for: • Provision of flood mitigation measures • Improved drainage and riverbank protection • Adoption of smart irrigation technologies • Coastal protection.

[108] Taga, R. & Smith, R. (2021). *A River Gravel and Sand Extraction Guideline 2021*. Compiled by Dr Raijeli Taga and Robert Smith. Fiji Ministry of Lands and Mineral Resources. Development Minerals Technical Working Committee. In review.

[109] Ministry of Waterways and Environment, Republic of Fiji. Strategic Plan 2020–2024.

Ministry / Institution	Roles and responsibilities
	Department of Environment The Department of Environment has the following responsibilities: • Protection of the natural resources • The control and management of developments • Ensuring EIA regulations in relation to aggregates extraction and other developments are implemented as provided for under the Environmental Management Act. • Waste management and pollution control • Establishment and oversight of a National Environment Council. • In general, the Department of the Environment is responsible for the formulation, coordination, and monitoring of the implementation of Fiji's national environmental policies, programs, and legislation to ensure sustainable development and utilization of Fiji's natural resources.
Ministry of Lands and Mineral Resources	**Department of Lands**[110] The Department of Lands has the responsibility for issuing licenses for sand and gravel extraction on native, freehold, and state land under the Rivers and Streams Act. Its jurisdiction is limited to: ○ Rivers and stream beds ○ Extractions for the purpose of public access/public enjoyment. • Issuing licenses for quarries under the Quarries Act but only in circumstances where material is destined for a rock crusher or treatment plant. • Surveying the boundary of extraction license sites • Managing the extraction from the beds of rivers and streams • Ensuring proper & relevant access to extraction sites • Receiving royalty payments for sand and gravel extraction from waterways & quarries • Sanctioning Licensees who breach license provisions. • Ensuring Licensees have obtained necessary environmental approvals from the Department of Environment **Mineral Resources Department (MRD)** • Issuing licenses for sand and gravel extraction for the specific purpose of delivering to a crusher (i.e., for quarry operations) • Managing the extraction from the beds of rivers and streams • Ensuring proper & relevant access to extraction site • Monitoring extraction volumes to ensure they are consistent with royalty payments by operators to Mines Inspectors (every 6 months) and, in the case of quarry operators, to inspectors from the MRD • Monitoring extraction from rivers to ensure Licensee is operating in accordance with terms of the license, including those related to environmental management (e.g., Environmental Management Plans).
Ministry of Employment, Productivity & Industrial Relations	**Labour Standards Service**[111] The Labour Standards Service has the following responsibilities: • Labor inspection and compliance, including: ○ Employer/workplace audit ○ Inspection, awareness, and training on employment conditions ○ Prosecution of offences under the Employment Relations Act ○ Managing, monitoring child labor ○ Advocacy and promotion of issues related to child labor • Labor complaints resolution • Registration and general administration of Trade Union related matters including processing of employment disputes in accordance with the Employment Relations Act 2007 **National Occupational Health and Safety (OHS) and Workers Compensation Service** • OHS training and accreditation, including providing training to employers and workers • Provide OHS awareness to government and other stakeholders

[110] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme.

[111] Ministry of Employment, Productivity & Industrial Relations. https://www.employment.gov.fj/index.php . Accessed 19/09/2023.

Ministry / Institution	Roles and responsibilities
	• Promote the Health and Safety at Work Act, including its regulations and Codes of Practice • Provide advice on establishing OHS representatives, committees, policies and programs • Develop OHS standards, regulations, codes of practice, systems and procedures • Act in an advisory role to the National Occupational Health and Safety Advisory Board • Processing and payment of workers compensation for work-related injuries or disease, including to dependents of those who have lost their lives as a result of workplace accidents or diseases.
Ministry of iTaukei Affairs	**iTaukei Lands and Fisheries Commission (TLFC)** • Confirming the rightful fishing rights owners of extraction sites to be developed • In consultation with the Ministry of Fisheries, calculate compensation for fishing rights owners • Confirmation of traditional customary land titles, landownership, and boundaries, including confirmation of traditional fishing grounds boundaries • Investigate cases challenging TLFC decisions **iTaukei Affairs Board** • Receive on behalf of iTaukei owners $0.50 of the $2.18 royalty paid by river gravel and sand extraction operators to the Director of Lands for extraction licenses[112] • Hold in trust this component of the royalty payment until distribution to the respective land-owning unit **Provisional Council Offices** The Councils' responsibilities involve executing the responsibilities of the TLFC (see above) at a provincial level, for example: • Validating the identity of respective landowning Units to the TLFC • Facilitating and managing meetings of landowning Units with a stake in proposed developments, including explaining formal processes and requirements • Facilitating and managing meetings of landowning Units with government agencies and private organizations with regard to formal processes and requirements • Authenticates the free, prior, and informed consent of landowning Units with regard to proposed developments and reports this to TLFC
iTaukei Lands Trust Board (TLTB)	• The TLTB issues licenses for sand and gravel extraction on iTaukei land under the iTaukei Land Trust Act and in line with Common Law • Surveying extraction site boundaries • Sanctions operators who breach conditions • Receives royalties paid by operators in accordance with the Gravel Regulations and then distributes them to relevant iTaukei landowners • Monitors operations to ensure compliance with license conditions
Ministry of Fisheries	• In consultation with the TLFC and relevant provincial office, the ministry calculates the and processes appropriate level of compensation to be paid to fisheries owners.

Source: based on Smith et al. 2018, updated with recent information from respective ministries

Site management, monitoring compliance and enforcement

There are significant problems with river extraction in Fiji, as demonstrated in numerous media articles in recent years documenting adverse environmental and social impacts.[113] This was also a major finding of the 2018 Baseline Assessment of Development Minerals, which identified issues such as contamination of river water used by households, impacts on tourism activities, and negative ecological effects. The government also recognizes this and during the course of the baseline assessment (2017–2018), Fiji's Minister for Lands and Mineral Resources indicated an intention to

[112] Chute, I. (2022). 'Dr Taga clarifies payment of royalties issue'. The Fiji Times. 20 June. https://www.fijitimes.com.fj/dr-taga-clarifies-payment-of-royalties-issue/ Accessed 12/09/2023.

[113] Kumar, R. (2023). 'Gravel extraction in Navua: Residents tell of sorry tale'. The Fiji Times, 1 April. https://www.fijitimes.com.fj/gravel-extraction-in-navua-residents-tell-of-sorry-tale/ Accessed 12/09/2023.

phase out river gravel extraction and to transition to a network of hard rock quarries.[114] Similarly, Fiji's Roads Authority also announced that it will no longer purchase river gravel for new road construction contracts. This transition though, is proving to be very challenging, something predicted by the Baseline Assessment, which concluded that:

> *initiatives will be needed to improve access to finance, review royalty and licensing application fees (which currently favour gravel extraction), undertake business process mapping on licensing procedures, create templates for partnerships with iTaukei landowners, and promote domestic investment through a collaboration between the Mineral Resources Department and Investment Fiji.*

There is also a major problem with illegal river extraction, including cases where some operators are breaching the terms of their licenses to extract only on iTaukei lands by extracting from river and stream beds, which is the jurisdiction of the government (Department of Lands) and not the TLTB.[115] In such cases, this means the government, and potentially, landowners, do not receive royalties.

Royalty rates for quarries and river extraction differ, depending on the type of resource and institution with authority. The below royalty rates applied at the time of the 2018 baseline, which even then, were considered outdated and need of revision (Table 15).

Table 15: Royalty Rates for Different Quarry Types

Institution	Type of extraction	Royalty rate
Dept. of Lands	River extraction sites	F$ 2.50/m^3
TLTB	Hard rock quarries	F$ 3.32/m^3
	Soft rock and sand quarries	F$ 6.61/m^3

TLTB = iTaukei Land Trust Board.

Source: Smith et al. 2018

Like most PICs, Fiji does not have a publicly accessible database of all regulated quarry and river gravel extraction sites. Indeed, the consultants have had to request data from both the DoL and MRD and are still waiting to receive data for aggregates extraction on iTaukei land. Fiji is in need of a comprehensive geographic information system (GIS) database of all extraction sites, which would enable a coordinated response to monitoring and enforcement by all relevant institutions.

The 2018 Baseline found that some 16% of all regulated extraction sites were completely unmonitored, other than at the time of license approval. It is not clear whether this number has increased or decreased since then. MRD, which was a major partner in the baseline, reported that it had 108 positions in its organization, but only 75 of these were filled, which highlights the capacity constraints faced by this Department and, probably other organizations like TLTB.

[114] Franks et al. (2020). Case Study 1: Phasing out River Gravel Extraction in Fiji. In World Bank (2020). *2020 State of the Artisanal and Small-scale Mining Sector*, Washington, D.C.: World Bank. Available https://www.delvedatabase.org/uploads/resources/2020-SoS_SHG-1_Fiji-River-Gravel.pdf. Accessed 12/09/2023.

[115] FBC News (2017). Stop Order Issues for River Gravel Extraction. https://www.fbcnews.com.fj/news/stop-order-issues-for-river-gravel-extraction/.

3.4 Kiribati

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Kiribati	**High** Large infrastructure pipeline with approved projects from Kiribati's NIIP (2022-2032) valued at a $562.37.	- Lagoon sand / gravel - Dolomite / limestone (Banaba island only)	**Low** 2020–2022 imports: ~8,042 tons 2020–2022 exports: 0[116] Successful sand extraction operations (ESAT) in Tarawa but (with the exception of the unrealized Banaba dolomite resource) no other types of aggregate, which makes it highly reliant on imports of hard rock, gravel etc. from countries like Fiji.

3.4.1 Geography and geology

The Republic of Kiribati is an island nation in the Central Pacific, comprising 32 atolls and reef islands and one upraised limestone island. These islands and atolls are located in three separate archipelagos spanning the equator with a total area of 811 km^2 and encompassing some 3.5 million km^2 of ocean (Figure 33). From west to east, these are the Gilbert Islands, Phoenix Islands, and the Line Islands. Kiribati has an estimated population of 124,738 with 59% of living on Tarawa Atoll, and most of these living in South Tarawa, which has 53% of the country's population.[117]

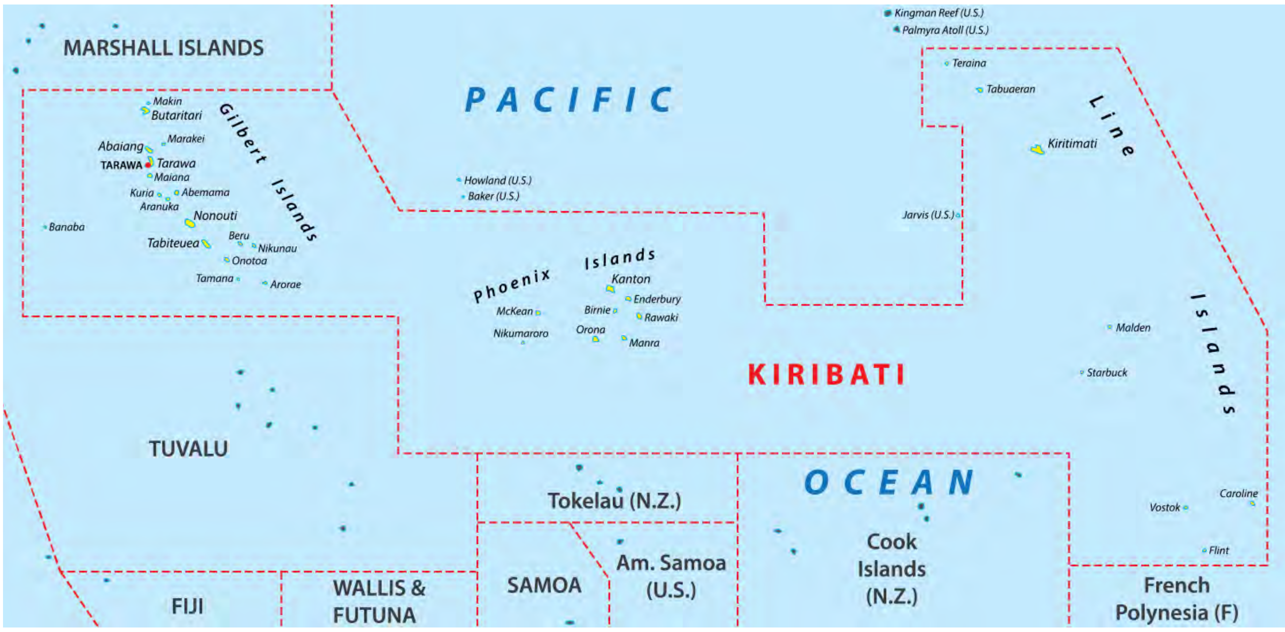
Tarawa is the capital of Kiribati and Tarawa Atoll is situated in the center of the western archipelago. Tarawa itself is often described as north Tarawa and south Tarawa. South Tarawa is densely populated; consequently, the demand for aggregates is high (Figure 33).

The western archipelago of the Gilbert Islands is where the two islands of interest for sustainable aggregates are located. They include Tarawa Atoll and the upraised atoll of Banaba formally known as Ocean Island. Banaba is located about 240 Nm or 444 km southwest of Tarawa. Banaba was known for its phosphate resources and was mined for phosphate from around 1908 to 1978.

[116] UN Comtrade data show exports of 5.4 tons of coarse aggregates to Thailand in 2020. This is almost certainly a mistake or due to double handing / onward shipping.

[117] Kiribati Census Atlas. (2022). https://sdd.spc.int/digital_library/kiribati-census-atlas-0. Accessed 27/12/2023.

Figure 33: Location of the Republic of Kiribati



Source: worldatlas.com

Figure 34: Tarawa Atoll

Source: Google Earth 13-10-2023

Geology of Kiribati and other Pacific atoll islands

This section describes the geological processes that have formed the atolls and, importantly, lagoon sediments not only in Kiribati, but other atolls in the Pacific, particularly those in the RMI and Tuvalu. Readers are therefore encouraged to refer to this section when reading the geological profiles for those countries since they will be similar to those described here.

Atoll islands like Kiribati, the RMI, and Tuvalu sit atop the Pacific Plate and are thought to be the remnants of an old volcanic chain produced by a long-inactive hotspot. For example, in the case of the RMI, it is likely that the parent volcanoes on which the atolls developed were formed just south of the equator in shallower water and then collected a vast thickness of carbonate deposits on sub-aerially eroded volcanic pedestals as they moved slowly north on the Pacific Plate.[118]

It is now widely known that the reef rim on modern atolls is underlain by older Pleistocene reefs,[119] something well illustrated in the multibeam bathymetry mapping of several atolls, including Majuro Atoll[120] and Manihiki and Penrhyn atolls in the Cook Islands from surveys in 2001 and 2003.

Within the chain of atolls stretching from Tuvalu through Kiribati and into the RMI, the depth of the lagoons varies. The Tuvalu atoll lagoons are reasonably deep (upwards of 50 m), Kiribati's atoll lagoons are relatively shallow (often less than 30 m and this only occurs in passages), while the RMI atolls are in excess of 70 m. This depth variation has implications when searching for suitable lagoon aggregate deposits in particular for use as construction material. In many cases, a broad relatively flat lagoon seafloor overlies an erosional surface, which, in many cases, can be karstic in nature.

Based largely on studies of the Majuro atolls, it has been proposed that Pacific atoll islands consist of two principal units - shallow Holocene deposits and underlying Pleistocene deposits.[121] The Holocene deposits are typically comprised of back-reef sands, gravels, and silts, 10–25 m in depth, which tend to be coarse-grained materials on the ocean side of islands and finer-grained sands on the lagoon side. Underlying these deposits is a thick sequence of Pleistocene sediments, which are weakly compacted and highly permeable.

Origin of sediments in atolls

Nearly all sediments in coral atolls are made of calcium carbonate derived either from the reef framework or from the skeletons of organisms that live on it.[122] The very small amount of non-carbonate material (usually <0.1 % of the total) consists of siliceous material (e.g., from sponge skeletons and human detritus) and other materials. The carbonate material is formed by the living organisms of the atoll itself, especially those forming and living on the ocean reef flat rim, which is the most productive area. Coral is broken down mechanically by wave and current action or biologically by boring and corroding organisms (known as bioerosion). Along with the shells of smaller organisms the broken-down coral contributes to the sediment. All fragmental (clastic) material is further broken down by abrasion during transport. Sediment is then distributed by ocean transport processes, with some filling spaces within the reef framework, some being transported into deep

[118] Scott, G and Rotondo, G. (1983). A Model for the Development of Types of Atolls and Volcanic Islands on the Pacific Lithospheric Plate. The Smithsonian Institution. Washington D.C., USA.

[119] Woodroffe, C.D. and Biribo, N. (2011). Atolls. In D. Hopley (ed.), *Encyclopedia of Modern Coral Reefs: Structure, Form and Process* (pp. 51–71). The Netherlands: Springer. https://ro.uow.edu.au/scipapers/1060

[120] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

[121] Hamlin, S.N., and Anthony, S.S. (1987). Ground-Water Resources of the Laura Area, Majuro Atoll, Marshall Islands. *US Geological Survey Water-Resources Investigations Report* 87-4047; Peterson, F. (1997) Hydrogeology of the Marshall Islands. In L. Vacher and T. Quinn (eds.) *Geology and Hydrogeology of Carbonate Islands*. Elsevier Science.

[122] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

water off the ocean reef edge, and the remainder being transported into the lagoon. Sediment production is thus a mix of biological and physical processes, but for most atolls, the details and relative importance of these various processes are still not well understood. Storms, waves, and human activities also break coral from the reef, depositing materials elsewhere in the atoll system. A good example of this is the rubble banks deposited on the ocean side reef flat of Fongafale, Funafuti Atoll in Tuvalu following cyclone Bebe in 1992.

The reef is also subject to attack by grazing species, such as parrot fish, which produces sand-sized sediment. In addition, skeletal and shells are susceptible to attack by a wide range of boring (endolithic) organisms, such as include cyanobacteria, fungi, sponges and mollusks.[123] Interestingly, few living corals show evidence of boring, which suggests they can deter boring micro-organisms. However, dead coral is extremely vulnerable to the microboring processes, which weakens the structure and breaks it down into small, sand-sized particles.[124]

Many species of foraminifera occur in lagoon sediments. The most important in terms of contributing to sediment formation are generally species larger than 1 mm in diameter and up to 10 cm, which commonly have symbiotic zooxanthellae in their tissues. They are important for sediment production because of their relatively large size, which means that even the smaller individuals are calcified as sand-sized particles. In atoll contexts such as Majuro Lagoon in the RMI, foraminifera that play an important role in sediment formation are Calcarina gaudichaudi, Marginopora vertebralis and Amphistegina lobifera (Figure 35). Most foraminifera productivity here appears to occur on the ocean reef flats of the northern and western sides of the atoll, from low tide to probably about 10 m below the surface on the reef edge. Other, minor, components of the sediment may include whole shells or clasts of echinoids, mollusks, smaller foraminifera, and human detritus.[125]

Figure 35: Common Foraminifera Found in Lagoonal Sands in Majuro Atoll

Source: Smith and Collen 2004

A conceptual geological framework of atoll islands, which is based largely on studies of the Majuro atolls,[126] consists of two principal units, the shallow Holocene deposits, and underlying Pleistocene deposits. The Holocene deposits typically consist of 10–25 m of largely unconsolidated back-reef sands, gravels, and silts. These deposits often are composed of several heterogeneous sublayers, which generally grade from coarse-grained material on the ocean side of the island to finer-grained

[123] Perkins, R.D., & Tsentas, C.I. (1976). Microbial Infestation of Carbonate Substrates Planted on the St Croix Shelf, West Indies. *Geological Society of America Bulletin*, 87: 1615–1628. See also Perry, C.T. (1998). Grain Susceptibility to the Effects of Microboring: Implications for the Preservation of Skeletal Carbonates. *Sedimentology*, 45: 39–51.

[124] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

[125] Ibid.

[126] Hamlin, S.N., and Anthony, S.S. (1987). Ground-Water Resources of the Laura Area, Majuro Atoll, Marshall Islands. *US Geological Survey Water-Resources Investigations Report* 87-4047.

sands on the lagoon side. Underlying the Holocene deposits is a thick sequence of Pleistocene sediments. Pleistocene deposits are characterized by weak lithification and partial dissolution.

Geology of Banaba

Prior to the removal of the phosphate capping during mining, Banaba took on the appearance of a flat-topped dome. The island is almost circular except for a bight along the southern coast known as Home Bay, where the fringing reef is at its narrowest. At the coastline, a narrow fringing reef with eroded cliffs varying in heights of 2–10 m surrounds the island. The fringing reef width varies: on the west coast it is up to 120 m wide, on the east coast 50 m, and the widest section is 150 m on the southern point at Ooma. Banaba's interior forms an elevated tableland rising to a height of about 80 m with a few surface depressions.

Banaba exhibits "spur and groove" features that are well preserved in the cliff shoreline along the western coast forming many little bays with small pocket beaches. Much of the northern and eastern coastline appears smoother with a contiguous beach lining the coastal strip and the spur and groove features seen exposed along the western coastline are noticeably absent. The cliffs along the north coast are higher than elsewhere on the island.

Banaba's geological structure emerged from similar processes to those occurring in Nauru, i.e., the seafloor eruption of basalts produced by rupture of the Pacific plate, followed by the construction of a volcanic pedestal and subsequent coral formation. The island consists entirely of coral formation and is also covered with extensive phosphate deposits, or guano. The coral-rock is highly weathered and rises into high pinnacles in many places. The rocks are in many cases composed of fragments of calcareous rocks cemented together into a compact mass.

3.4.2 Summary of aggregate extraction sites and known resources

Tarawa's lagoon aggregates and the ESAT project

In February of 2008 the Government of Kiribati / European Union signed a financing agreement for a project implemented by SOPAC and was intended to support Kiribati in combatting coastal erosion on its most densely populated atoll, Tarawa. The project is known as Environmentally Safe Aggregates for Tarawa (ESAT). Tarawa atoll faces severe coastal erosion problems that have resulted in the loss of land, wave inundation, and flooding of businesses, houses, and critical infrastructure. The ESAT project aimed to "protect the vulnerable beaches of South Tarawa from damage caused by aggregate mining and provide an alternative supply of material through environmentally safe lagoon dredging in an area now known as the ESAT resource area", which is shown in Figure 36.[127]

The specific objectives of the project were to:[128]

- Protect the vulnerable beaches of South Tarawa from perturbation caused by aggregate mining and
- Provide an alternative supply of appropriately sourced material to meet South Tarawa's growing demand though three interconnected components:

[127] SOPAC (2011). Environmentally Safe Aggregates for Tarawa (ESAT) Project Terms of Reference for Technical Assistance to Establish the Community Participation Programme. http://gsd.spc.int/sopac/docs/Community%20Participation%20Programme_Advert%20final.pdf. Accessed 10/09/2024.
[128] SPC (2017). Government of Kiribati-EU-SPC Environmentally Safe: Final Narrative Report. 5 February 2008–31 December 2016. Geoscience Division, Pacific Community.

1) establishment of a commercially self-sustaining aggregate company and environmentally safe lagoon dredging operation;
2) implementation of effective control of beach mining; and
3) building community support for mobilizing alternative sources of aggregates and ensuring public access to lagoon aggregates.

The ESAT resources area were first defined in 1994 based on bathymetric mapping, seismic reflection data and jet probing in an area north of Betio on the western margin of the drowned barrier reef of the atoll.[129]

Figure 36: Sketch Illustrating the Location of the Site for Detailed Investigation

Image of Tarawa taken from Google Earth

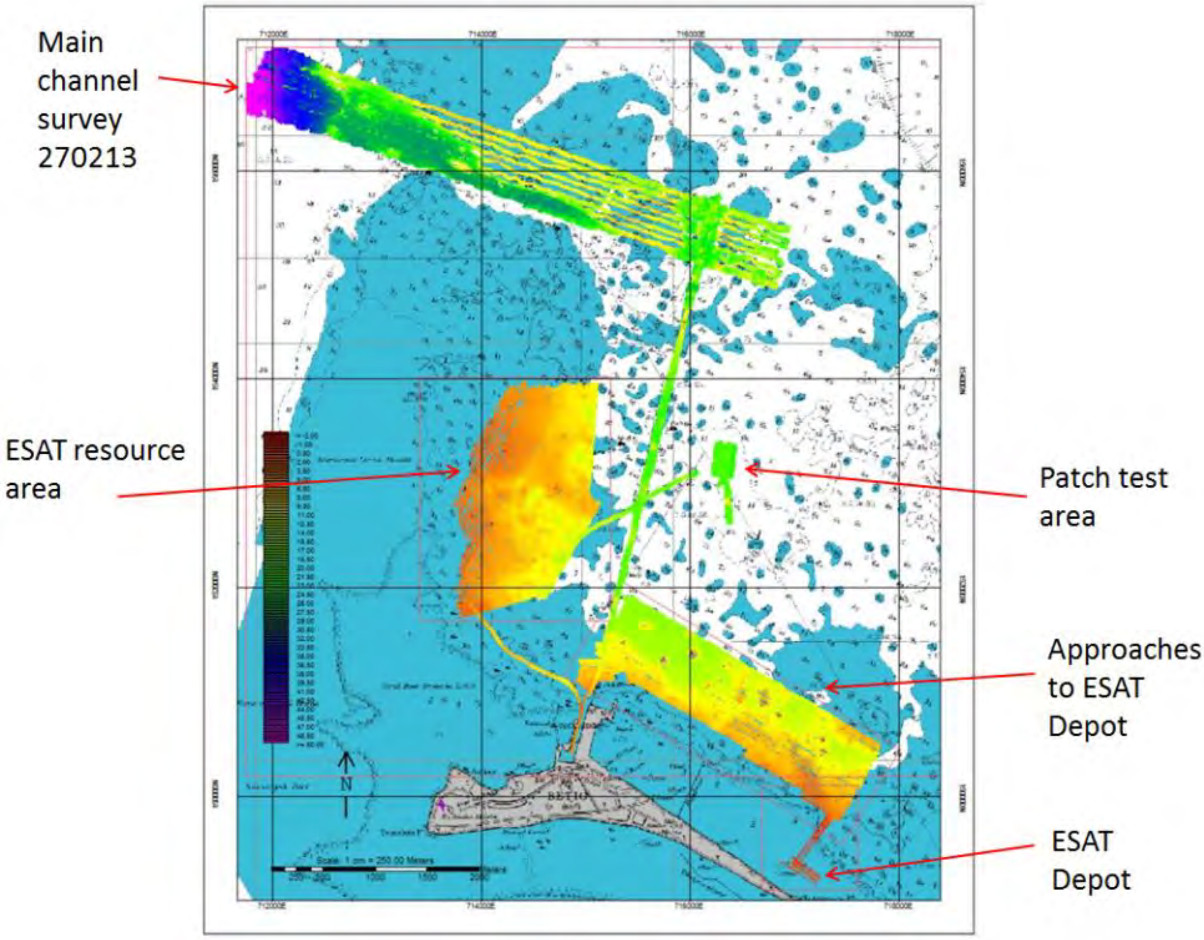
To support the project, additional survey work was conducted in 2013, 2014, and 2015. This work included multibeam bathymetry and magnetics for an unexploded ordnance (UXO underwater survey and resultant clearance, which was a requirement for dredging in the ESAT resource area in Tarawa Lagoon.[130] The area was approximately 2.27 km^2 in size. In addition to this work, the establishment of the new ESAT depot, an access channel to the existing near shore borrow pits was required to be dredged but first required an ordnance clearance survey (ESAT = Environmentally Safe Aggregates for Tarawa.

Note:).

[129] Smith, R., Young, S., and Biribo, N. (1994). Bathymetric, Seismic, and Alternative Sand and Gravel Resource Surveys, Tarawa Atoll, Kiribati. *SOPAC Preliminary Report* 72: 18 p.; figs., 3 app.

[130] Smith, R. (2013). ESAT Resource Area UXO Survey, Tarawa Lagoon Kiribati. *SPC SOPAC Division Technical Report Preliminary* R173. See also Smith, R., and Yeating, K. (2013). An Evaluation of the Remaining Phosphate Deposits on Banaba Island. *SOPAC Technical Report* 430.

Figure 37: Areas Surveyed for ESAT Project 2013, 2014.



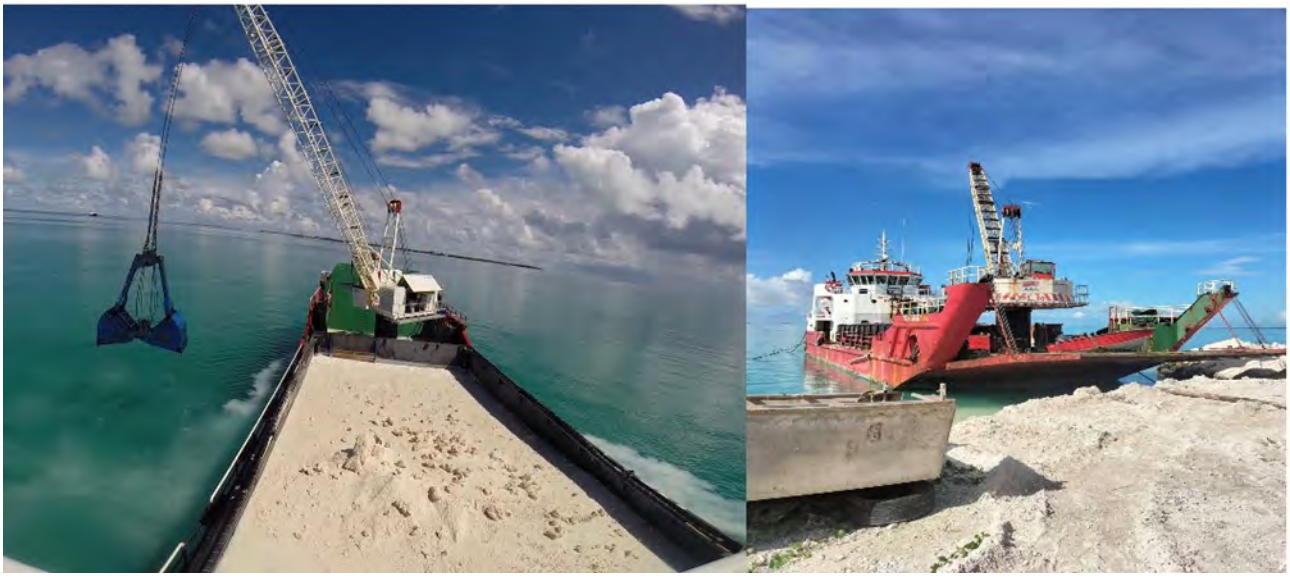
ESAT = Environmentally Safe Aggregates for Tarawa.

Note: base map is the Baseline Assessment chart for Tarawa.

Source: Compiled by Smith from surveys in 2013 and 2014

The Kiribati sand and gravel aggregates state-owned enterprise, Te Atinimarawa Co Ltd (TACL), was established by the ESAT project in 2013. To mine the aggregates, a dredge with 300-ton capacity and clam shell was procured as part of the project. A beneficiation plant was also set up on the southern end of Betio and an access channel dredged to allow the dredging vessel to beach and discharge the sand using a front-end loader (Figure 38).

Figure 38: Right - Barge Dredging in Resource Area, 2014; Left - Barge at the Company's Beneficiation Site in Betio at the ESAT Depot



Source: left photo Robert Smith, right photo Gary Lee, SPC 2022

TACL has an exclusive Environment License to operate in the resource areas that have been identified including its boat channel when it becomes shallow. TACL has also been requested to maintain existing boat channels and to dredge new ones (

).[131]

Figure 39: Clearing the Small Boat Channel in the Betio Bariki Causeway of Sand

Photo credit: unknown

131 Personal correspondence Director of Geology and Coastal Management in an email 12/09/2023.

The company has also been requested to support disaster from natural hazards risk reduction efforts by raising the ground level of low-lying areas impacted by floods and cyclone swells. However, TACL's current dredging capacity to support additional work is considered a challenge. Its equipment is operating well but with high maintenance costs, though to date they have managed to sustain their operation with small returns. Figures for company product sold from 2016 to August 2023 are presented in Table 16.

Table 16: Sales of Aggregates Dredged by Te Atinimarawa Co Ltd , 2016–2023

Year	Project Aggregates sold m^3
2016	29,000
2017	17,200
2018	37,000
2019	18,300
2020	22,149
2021	17,000
2022	18,811
2023 (January–August)	22,887
Total	**182,347**

source: personal correspondence with MFMRD

With respect to the building of seawalls and reclamation by local landowners the Ministry of Fisheries & Marine Resource Development (MFMRD) runs a monitoring program, which shows that there have been 45 seawall and land reclamation project applications between 2011 and 2023. These projects have resulted in 1,453.5 m of seawall being built, and 7,900 m^2 of land reclamation completed. Seawall material used include concrete, cement block, sandbags, rocks, and coral stone. Concrete represents over 50% of the materials used.[132]

Aggregate imports 2019–2022

Table 17 is a listing of aggregates imported into Tarawa between 2019–2022, as reported by the Director of Geology and Coastal Management Division.[133] Fiji is the major source of aggregates imported into Tarawa. Data pertaining to the use of the aggregates imported were not provided.

Table 17: Aggregate imports into Tarawa, 2019–2022

Commodity Description	Unit	Quantity	Value	Country
	2021			
Pebbles, gravel broken or crushed stone	kg	2,349,150	$162,867	Fiji
	2020			
Pebbles, gravel broken or crushed stone	kg	533,190	$173,696	Fiji
Pebbles, gravel broken or crushed stone	kg	352,000	$110,218	USA
	2019			

[132] Personal communication with Director of Geology and Coastal Management Division within MFMRD for data on seawalls, legal issues. TACL data also used.

[133] These data do not align with UN Comtrade data. For instance, the aggregate imports from Fiji reported by the Geology and Coastal Management Division in 2021 are twice those reported by Comtrade. 2,349,150 vs 1,303,150.

Commodity Description	Unit	Quantity	Value	Country
Silica sands and quartz sands	kg	4,000	$710	Fiji
Other (natural sands of all kinds)	kg	174,260	$54,796	Fiji
Pebbles, gravel broken or crushed stone	kg	196,735	$386,950	Fiji

Source: Director Geology & Coastal Management Division

Aggregate Resource potential of Banaba Island

There have been previous studies to understand Banaba's aggregate resource potential. Scholars have focused on limestone / dolomite pinnacle dimensions and specific gravity to convert volume to tonnage 100 m^2.[134] As an example, an average pinnacle size of 1x1x3 m high would contain some 6.5 tons of aggregate, which would translate into 50 tons per 100 m^2. However, this figure is likely to vary considerably around the island as would size. For example, pinnacles in the central mining area are reported to be on the order of 10 m to 20 m high based on reported mining depths, meaning estimates may be significantly less than the true aggregate resource potential. One estimate, based on a topographic map of just five areas of the former phosphate mining lease indicated there could be as much as two million tons of aggregate.[135]

Recently, Members of Parliament from Banaba and Rabi requested government assistance with alternative development plans for the island, noting that Banabans cannot benefit from copra alone. As a first step, Kiribati government agencies, including the Geology and Coastal Management Division under the MFMRD, were tasked to look into potential areas for aggregate supply on the island.

During investigations, an appraisal team used an aerial drone to estimate the amount of aggregate resources on the island but with low resolution. Meanwhile, an international mining company has shown interest in mining the limestone, secondary phosphate, and other minerals and metals on the island as part of rehabilitation actions. However, movement on this proposal is pending and controversial, given the environmental and other impacts of phosphate mining on the island in the paste. The government is reportedly considering seeking technical and legal assistance of the Intergovernmental Forum of Mining, Minerals, Metals, and Sustainable Development and to see where Kiribati can receive support for evaluating such a proposal. Nevertheless, it is believed that Banaba can be a significant source of aggregate that could sustain Kiribati's needs and be a potential exporter into the future.

Challenges to realizing Banaba's aggregate resource potential

Accessibility

Banaba is remote and the existing infrastructure to support any aggregate extraction is currently not available on the island. One field visit in 2008 observed that the island was experiencing drought conditions and as a result vegetation coverage was sparse and terrain exposure good. Many roads were passable, which allowed access into many of the mined areas where the aggregate resources in the form of pinnacles was present. However, in a visit to Banaba in 2014, heavy vegetation limited visual appraisal of potential resource areas (Figure 40) and many of the roads were no longer passable, especially into the mined areas.

[134] Taylor, G. (2005). *The Geology, Mining History, and Phosphate Resources of Banaba, Western Equatorial Pacific, Republic of Kiribati*. Draft consultancy report prepared on behalf of Rabi Council of Leaders and the Government of the Republic of Kiribati. Suva, Fiji: South Pacific Geoscience Commission.

[135] Smith, R., and Yeating, K. (2013). An Evaluation of the Remaining Phosphate Deposits on Banaba Island. *SOPACTechnical Report* 430.

Figure 40: Extensive Vegetation Due to Good Rainfall Cover and Hiding Pinnacle Fields

Photo credit: Robert Smith, 2014

Equipment challenges and solutions

The lack of heavy earth-moving equipment on the island precludes any mining activity at this point. At a minimum, a front-end loader could be used to collect lose boulders and generate a stockpile for shipping at a later date. Even with the heavy vegetation cover, it may be possible to mine such loose aggregate.

In addition, by using such equipment as a Shaw handheld core drill and expanding concrete (cold demolition, e.g., Sylentmite) (Figure 41), it may be possible to mine the pinnacles and break then into smaller pieces for ease of handling at a cottage industry scale. Typically, it takes about 15 minutes to drill a 41 mm diameter to a depth of 50 cm. SPC's Geoscience Division has successfully deployed this drill system drilling limestone in Niue down to depths of 6 m.

Figure 41: Drilling Limestone/Dolomite Boulders near Roadside

Shaw backpack drill

Rock cracked with sylentmite

Photo: Shaw Portable Drills

Shipping out of Banaba

There are no vessels suitable on island for transporting aggregate from island to ship. The harbor is small and often subject to surge from ocean swell. The steps shown on the left in Figure 42 are also exposed and the surface is extremely slippery. There is an old gantry system for lifting out service tugs but this has all but collapsed.

Figure 42: Banaba Harbor at Low Tide

Photo credit: Robert Smith, 2014

Adjacent to the harbor is an extensive fringing reef flat, which is passable for loading and unloading vessel with bow ramps. This is illustrated in Figure 43. This reef flat has been used in the past for discharging cargo from bow ramp vessels as shown in Figure 44. However, a fully laden vessel of aggregate may have difficulty retreating or backing off the reef and suffer possible hull damage in the process. There are reports that the government has since built a loading ramp across the reef flat but this is yet to be confirmed.

Figure 43: Fringing Reef Flat That Is to the West of the Harbor

Photo credit: Robert Smith, 2014

Figure 44: Landing Craft on Reef Flat Adjacent to Harbor in Banaba

Photo credit: Robert Smith, 2014

3.4.3 Aggregates required for national infrastructure development

National Development Planning

Kiribati's 20-Year Vision 2016–2036 is a policy and strategies document aimed at developing Kiribati in the next 20 years across four main areas: wealth; peace and security; infrastructure; and governance.[136] The plan focuses on the sustainable sourcing and use of seabed minerals, but there is no mention of extraction of terrestrial resources including aggregates and construction minerals.

With the support of PRIF, Kiribati developed its first NIIP in August 2023. This plan aligns with the country's Development Plan 2020–2023, which also focuses on infrastructure development as one of its pillars. The NIIP provides an investment screening and prioritization framework to ensure that future infrastructure investments align with Kiribati's national development priorities for the next 10 years.[137] A unique aspect of the plan is that it has been prepared by incorporating lessons learned from other Pacific countries, such as ensuring clear ownership of the plan, integration with the planning and budget process, regular review of priorities, and others. The NIIP covers all sectors of the economy and comprises over 200 candidate infrastructure projects with a total value of $1.58 billion (A$3.43 billion), though not all will be funded within the NIIP timeframe due to financial and capacity constraints within government. The plan was prepared and will be led by the National

[136] Kiribati 20-year Vision 2016–2023. https://www.mfed.gov.ki/sites/default/files/KV20%20VISION.pdf. Accessed 25/09/2023.

[137] Kiribati National Infrastructure Investment Plan 2022–2023. www.theprif.org/sites/default/files/documents/Kiribati%20NIIP_web%20publication%20final_0.pdf. Accessed 07/12/2023.

Economic and Planning Office (NEPO) of the Ministry of Finance and Economic Development (MFED).

So far, 17 projects have been approved by Cabinet (in 2022) as a national priority and are likely to go ahead. These cover the following sectors: aviation, urban development, roads, energy, civil building construction, housing, marine, and telecommunications sectors. The total cost of these projects will be $388.03 million.[138]

Many of these projects will require very large quantities of aggregates for road sealing chip, concrete, and other purposes. Notable projects in this regard are the Betio Power Station Replacement ($40.3 million), Kiribati Outer Islands Transport Infrastructure Project Phase 2 ($41.8 million) and, especially, the Outer Islands Infrastructure (roads) Program ($149.6 million).

PRIF members have identified 10 key projects that they may support in coming years, as summarized in Table 18. Some of these projects are among the Category A prioritized projects from the NIIP (e.g., the Outer Island Maritime Infrastructure Project – Phase 2) though the budgets stated differ.

[138] Converted from Australian dollars using a 2022 average annual exchange rate of A$1 = $0.69

Table 18: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for Kiribati and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Outer Island Maritime Infrastructure Project – Phase 2	25.0 (TA 0.95)	Very High	This project will require a very high volume of aggregates as it involves significant infrastructure for ship-to-shore and land transport for selected islands. Aggregates will be required for concrete, asphalt, pavement layers and roads, and other facilities
Transport	Multi-purpose Port on Christmas Island	TBD	High	Requires high amount of aggregates for concrete and boulders for breakwaters, and other facilities
Energy	South Tarawa Renewable Energy Project – Phase 2	22.0	Depends on scope	Requires varying amounts of aggregates. Proper estimates are to be determined with a clear project scope. E.g., solar energy projects would require concrete for solar panel platform footings
Energy	Contribution to ADB-led Kiribati Climate Adaptive Renewable energy	14.0	Depends on scope	As above
Water and sanitation	Climate Resilience Sanitation Assessment	TBD	Depends on scope	Aggregates might be required in the post-assessment phase
Urban Development	Kiribati Institute of Technology campus upgrade	7.0	Low-Moderate	Requires low-moderate amount of aggregates for concrete for structures, walkways/footpaths and other support structures based on the final scope
Urban Development	Betio Hospital	25.0	High	Requires a significant amount of aggregates for buildings, service roads and other facilities.
Total ($)		**93.95 million**		

ADB = Asian Development Bank, TBD = to be determined, TA = technical assistance.

Source: PRIF 2023; relevant project reports where available

3.4.4 Overview of the legal and policy framework

Land and resource ownership

In Kiribati, land is categorized as customary and state-owned land. Most of the land belongs to the I-Kiribati (indigenous landowners), with exception of the Phoenix and Line Islands and small amounts of reclaimed land owned by the government confined to Temaiku Bight in South Tarawa.[139] Land is

[139] East Micronesia Cable Project (World Bank Project Number P130592, Asian Development Bank Grant Number D004-FM), Environmental and Social Impact Assessment. https://www.mict.gov.ki/publications/environmental-social-impact-assessment#:~:text=The%20EMC%20Project%20will%20require,conveying%20land%20based%20cable%20or. Accessed on 26/09/2023.

owned by families, and it is commonly distributed among members by the head of the family. The members have equal rights to use and access the land and its resources (groundwater, harvesting, fishing and social security).

Government, non-government organizations, and businesses can lease customary land on the approval of the landowners.

Native Land Ordinance 1977

Part VI (Leases) (section 10) states that native land leased to a non-native person, business or institution requires the approval of the Minister.[140] Section 11 indicates that any native person obtaining a native lease must submit the proposed lease to the court of the district or island where the land is located.

Non-Native Land (Restriction on Alienation) Ordinance 1974 (Amended 1977)

This states that land owned by a person other than a native person, not including land owned by the local government can be acquired by the state for public purposes.[141]

State Acquisition of Lands Act 1954 (Amended 2001)

This allows for alienation and acquisitions of native and non-native lands for public purpose such as sanitary improvements, infrastructure such as ports, railways, roads, government housing schemes or for the purposes connected with the construction, maintenance, or improvement for a highway or any other purpose declared by the government.[142] Alienation and acquisition of land could be for a fixed term or absolutely.

Land Planning Ordinance 1972 (Amended 1977)

This is a legal framework for land planning for specific purposes (e.g., commercial, industrial, residential, infrastructure, civic use, and open space).[143] This ordinance provides for the establishment of a Central Land Planning Board which, with the approval of the Minister, designates the land use for specific areas.

Foreshore and Land Reclamation Act 1969 (Amended 2005) and the Laws of Kiribati Act 1989

The Foreshore and Land Reclamation Act proclaims the state's ownership of the foreshore and seabed, subject to public rights and navigation.[144] The Laws of Kiribati Act acknowledges that customary rights can be applied to the ownership of any resources in connection with the sea or

[140] Food and Agriculture Organization of the United Nations. Native Land Ordinance. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035345/. Accessed on 26/09/2023.

[141] Food and Agriculture Organization of the United Nations. Non-Native Land (Restriction on Alienation) Ordinance. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035347/. Accessed on 26/09/2023.

[142] Food and Agriculture Organization of the United Nations. State Acquisition of Lands Ordinance. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035359. Accessed 26/09/2023.

[143] Food and Agriculture Organization of the United Nations. Land Planning Ordinance 1972 (Amended 1977). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035344/. Accessed 26/09/2023.

[144] Food and Agriculture Organization of the United Nations. Foreshore and Land Reclamation (Amendment) Act 2005. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC074408/. Accessed 26/09/2023.

lagoon area, inland water or foreshore, reef or seabed.[145] Due to the ambiguity in legislation, it is unclear whether marine aggregates are owned of the state or fall under customary law.

Environment Act 1999 (Amended 2021)

This is the main legislation that mandates for environmental protection and mitigates the impacts of major activities and projects, including the extraction and sourcing of aggregates from marine environments. If this extraction is for commercial or construction purposes, and in excess of 200 kg per year, it is considered to be an "environmentally significant activity" and therefore subject to an EIA report, as described below.[146]

The act provides for the roles of the Environment and Conservation Department (ECD) within the Ministry of Environment, Land and Agricultural Development (MELAD). The roles of ECD include advising developers on environment license requirements, the need for an EIA report and enforcing implementation of environmental safeguards.

Policies

The Environment Regulations 2017

These regulations outline the requirements that every developer must comply with when applying for and obtaining an environmental license.[147]

According to the regulations, all environmentally significant activities require EIA report when applying for a license. Such activities include:

1. those involving extraction of aggregates, stone, shingles, sand, reef mud and beach rock for commercial purposes, construction work and in excess of 200 kg/year;
2. clearance of live corals, mangroves and seagrass for commercial or construction work; and
3. dredging.

Environment license process

For any proposed activity/project, the developer has to apply for an environment license, which is approved by the Principal Environment Officer within MELAD.[148] The Officer then responds to the application by:

1. granting an environment license;
2. refusing to grant environment license; and
3. requiring the applicant to submit an EIA report.

[145] Laws of Kiribati Act 1989. http://www.paclii.org/ki/legis/num_act/loka1989162.pdf. Accessed 25/09/2023.

[146] Food and Agriculture Organization of the United Nations. Environment Act No. 18 of 2021. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC219828/. Accessed on 25/09/2023.

[147] Environmental Regulations 2017. https://kiribati.tradeportal.org/media/Environment%20Act%20General%20Regulations%202017-min_2.pdf. Accessed 25/09/2023.

[148] Government of Kiribati, Ministry of Information, Communication, Transport and Tourism Development and the Ministry of Infrastructure and Sustainable Energy (2020). *Kiribati: Outer Islands Transport Infrastructure Investment Project, Environmental and Social Management Framework*. https://www.adb.org/sites/default/files/project-documents/53043/53043-001-esmsf-en.pdf. Accessed 25/09/2023.

After the EIA report has been submitted the proposal is made open to the public before the Officer decides to grant or refuse the Environment License application.

Mineral Development Licensing Ordinance 1983 (Amended 1987)

According to Part II (s3) of the act, a license is required to conduct any reconnaissance, prospecting, or mining of any minerals.[149]

A reconnaissance license is required to identify the existence of mineral potential or initial targets of a potential mining operation. Licenses are valid for 2 years and can be renewed for up to 1 year.

A prospecting license is required to carry out prospecting operations. This license is valid for 3 years, subject to renewal.

A mining license can be granted to the holder of a prospecting license who has discovered minerals in commercial quantities in the area covered by license. Can be valid for a period not exceeding 25 years.

Royalties

According to Part VIII (s47), the holder of a mining license must pay royalties on any minerals obtained at the rate of 2% of the gross market value of the minerals. If the minerals are extracted from any area of the territorial sea, lagoon, inland water or government land, the royalties are paid to the government. In other cases where mining is occurring in customary land, the royalties must be paid to the government in accordance with a scheme approved by the Minister for the benefit of landowners and any individual whose rights, welfare, and interests are impacted by the mining operation.

3.4.5 The institutional and operating context

Ministry of Environment, Lands and Agriculture Developments

MELAD is the government agency responsible for safeguarding and managing the natural environment upon which economic development and human health depends. MELAD has three different divisions, including Agriculture and Livestock, Environment and Conservation, and Land Management.[150]

The Environment and Conservation Division

This Division is comprised of various units that implement the responsibilities and operational work programs within the Division, including the Compliance and Enforcement Unit, Development Control Unit, Environment Outreach Unit, Wildlife Conservation Unit, Biodiversity and Conservation Unit and Chemical and Waste Management Unit. The work within the division is guided and managed by the Director and the Deputy Director of the ECS who report to the Secretary of MELAD. The Compliance and Enforcement Unit and the Development Control Unit aim to ensure that environmental safeguard measures comply with regulations, including submission of the application and EIA documents to

[149] Food and Agriculture Organization of the United Nations. Mineral Development Licensing Ordinance. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC051663/. Accessed 26/09/2023.

[150] Ministry of Environment, Lands and Agriculture Developments. https://www.melad.gov.ki/index.php?option=com_quix&view=page&id=39&Itemid=338. Accessed on 27/09/2023.

MELAD, submitting applications for environmental licenses under the EIA Act, and with the Environment Regulations of 2017.[151]

The Land Management Division

This is the agency responsible for managing government-owned lands and leaseholds. The division maintains and updates the Land Register, also known as the Kiribati Land Information System (KLIS). There are three units within the division carrying out these responsibilities including the Land Registration and Information Unit, Land Planning and Urban Development Compliance Department and the Land Survey and Geographical Information System Remote Sensing Department.

Potential mining regulation changes

The Ministry has recently reviewed its act to license and regulate development activities including mining activities, that are subject to an EIA and environment licensing. There is a plan to update the Mineral Licensing Ordinance to reflect the current practices of mining activities in Kiribati, especially on beach mining, coral boulder extraction, boat dredging, TACL, and other proposals including any international mining company proposals received.

There is also a desire to expand the scope of the ordinance to cover Banaba, the Line and Phoenix groups, and be able to apply for royalty returns and compensation. Given the lack of capacities and experience the government has with minerals and mining activities, a recommendation has been made to register the Ministry's interest with the Intergovernmental Forum on Mining, Minerals Metals, and Sustainable Development (IGF) for assistance.[152]

Ministry of Infrastructure and Sustainable Energy

The Ministry of Infrastructure and Sustainable Energy is responsible for infrastructure development and maintenance to support transport, road maintenance, coastal protection, and public utilities.[153] The Ministry has several units including the Project Development Unit, which is responsible for the development and reporting of projects such as road upgrading and maintenance, coastal protection projects, health and medical infrastructure, desalination systems or climate change related projects.

Kiribati Fiduciary Services Unit

This unit is part of the Ministry of Finance and Economic Development. Its responsibility is to oversee environmental and social issues and ensure these are addressed within development projects.

[151] Government of Kiribati, Ministry of Information, Communication, Transport and Tourism Development and the Ministry of Infrastructure and Sustainable Energy (2020). *Kiribati: Outer Islands Transport Infrastructure Investment Project, Environmental and Social Management Framework*. https://www.adb.org/sites/default/files/project-documents/53043/53043-001-esmsf-en.pdf. Accessed 25/09/2023.

[152] Personal communication, Director of Geology and Coastal Management Division, Kiribati. Dated 12/09/2023.

[153] Government of Kiribati, Ministry of Infrastructure and Sustainable Energy. https://www.mise.gov.ki/. Accessed 20/12/2023.

Ministry of Fisheries and Marine Resources Development

MFMRD is responsible for sustainable development of Kiribati's fisheries and marine resources.[154] Its mandate includes development of domestic and joint ventures for tuna industries harvesting, processing and fish marketing and to coordinate development of coastal marine resources. It is also responsible for negotiating bilateral fishing access in relation to local and foreign fishing vessels, monitoring, control and surveillance and the management and harnessing of non-living deep sea mineral resources. MFMRD also undertakes scientific research and participates in international and regional fisheries conventions.

MFMRD has several divisions, including a Coastal Fisheries Division and a Geology and Coastal Management Division which has responsibility mineral resources in lagoons and coastal areas.

3.5 Republic of the Marshall Islands

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
RMI	**Low-medium** The Marshall Islands National Strategic Plan 2020-2030 does not provide detail on specific infrastructure projects however, PRIF members have identified 4 projects for potential support at a cost of $52.86 million.	- Lagoon sand / gravel	**Low** 2020–2022 imports: ~2,317 tons 2020–2022 exports: 0 tons Highly dependent on import of hard rock aggregate, including armour rock for coastal protection and other works. However, based on available information, infrastructure pipeline appears to be relatively modest, with the Majuro airport terminal ($32 million) likely to need the most aggregate resources for runways etc. Also, potentially good sand deposits at the northern rim of Majuro lagoon could meet some of this demand for this type of aggregate.

3.5.1 Geography and geology

The Republic of Marshall Islands (RMI) is located in the northwest Pacific (~171° E, ~7O° N), and consists of 29 atolls and five islands dived between two chains, Ralik chain and Ratak chain, which are orientated in a northwest-southeast direction. The 2021 Census estimated RMI's population at 41,575, of which over half reside in the capital city Majuro (Figure 45).

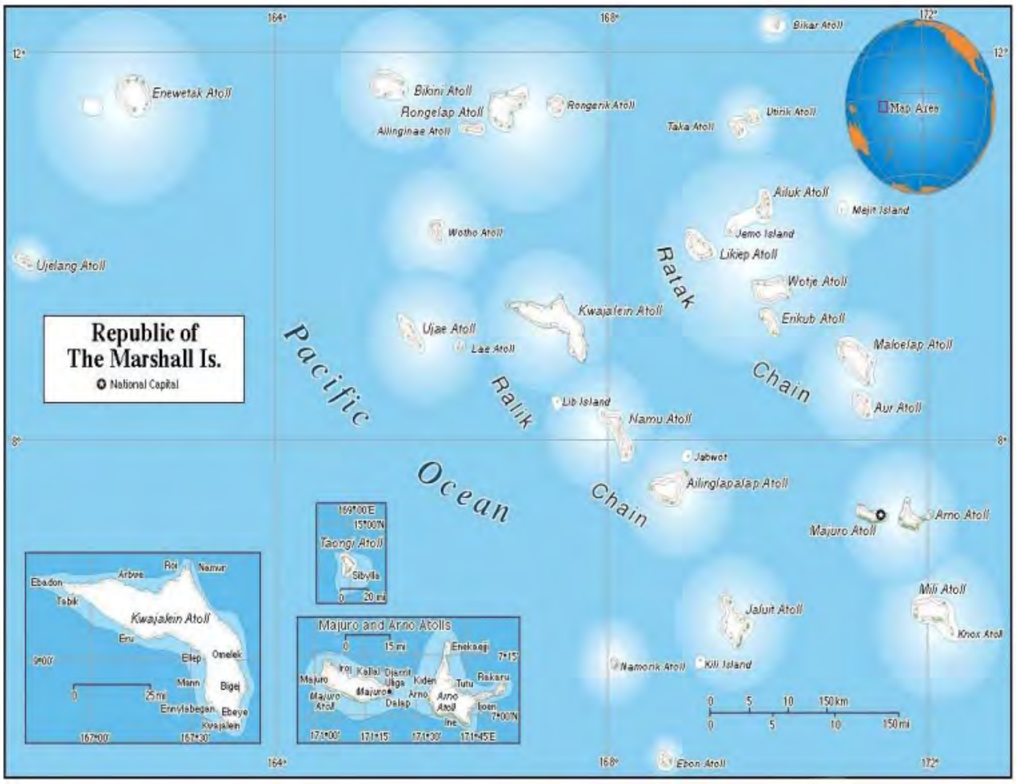
154 Ministry of Fisheries & Marine Resource Development. https://fisheries.gov.ki/ Accessed 06/12/2023

Majuro Atoll with a population of 22,873 (2021 Census) and Ebeye on Kwajalein Atoll with a population of around 10,000 people, are the most populated islands in the Marshall Islands.[155] The greatest demand for aggregates and rock armor is within these two atoll environments.

Majuro Atoll

Majuro Atoll is located in the southeast of the island chain at approximately 171° E and 7° N. The atoll is elongated in shape, approximately 40 km long in an east west direction, and 9.7 km at it widest in a north south direction. The lagoon area covers some 324 km^2 with depths in excess of 60 m and a land area of 9.7 km^2. It is the most populated atoll of the Republic and has the highest population density with approximately 20,000 of the total atoll population of 28,000 residing on three interconnected islets on the eastern side of the atoll, which are often abbreviated as "DUD" after the names of the three islets Delap, Uliga, and Djarrit.

Figure 45: Republic of the Marshall Islands



Source: PRIF website

Majuro lagoon is almost enclosed by a continuous reef flat with several passages in the center-west side of the north rim, in which a 3.2 km wide and 9–18 m deep passage is located west of Calalin Island. The southern side of the lagoon is fringed by an elongated island, and the southern boundary of the atoll is completely closed except for a small boat passage constructed in the southeast in Rairok east. The main passage between the lagoon and the outer ocean is Calalin Channel located in the center of northern atoll rim. Other smaller channels exist to the west of the Calalin Channel and these have now been mapped in detail with the acquisition of the 2019 LIDAR (Light Detection and Ranging) data.

[155] The population of Ebeye Island is not given in census data but is given for Kwajalein Atoll, which is where Ebeye is located. The vast proportion of Kwajalein's population are in Ebeye. See Republic of the Marshall Islands (2021). Census *Report: Volume 1: Basic Tables and Administrative Report*. Economic Policy, Planning and Statistics Office, Majuro. https://sdd.spc.int/news/2023/05/30/marshall-islands-2021-census-report-basic-tables. Accessed 06/12/2023.

Marjuro atoll has 64 islets covering approximately 6 km^2 with the majority located on the east, south, and eastern half of the northern rims of the atoll. Causeways have been developed over the past 40–50 years that have connected the islands from Djarrit in the east to Laura in the southwest, with most natural sea water channels entering the lagoon closed off.[156]

The closing of channels between islets have had serious consequences with the sediment cycle with the presence of causeway interrupting flow of sediments back into the lagoon from source, typically the ocean side reef of the atoll.

Geology

The RMI are situated on top of the Pacific Plate and are thought to represent an old volcanic chain produced by a long-dormant hotspot which moved slowly north with plate movement. In contrast to some linear volcanic island chains in the Pacific, the volcanoes that underlie the present-day RMI are widely dispersed and do not exhibit any chronological age unlike, for example, with the Hawaiian Emperor volcanic chain.[157]

The atolls of the RMI comprise circular to elliptical chains of small islands made from carbonate materials along with associated coral-reef platforms that encircle seawater lagoons. Researchers have interpreted the closed depressions in the lagoon bathymetry at depths of 30–35 m in atolls such as Bikini Atoll as sinkholes formed by circulating ground water during low sea-level periods in the Pleistocene.[158] Consequently, present day atoll morphology closely reflects a karstic landscape that has been submerged by post-glacial global sea-level rise. In addition, it is now widely understood that the reef rim on modern atolls has developed on top of older Pleistocene reefs.[159]

The primary sources of sediment in Majuro Lagoon are red and green calcareous algae, coral, and larger foraminifera.[160] The calcareous red algae (rhodophytes) are present as free-standing species and as encrusting and framework organisms that may be as important as coral to Pacific reefs. Storms, waves, and human activity dislodge coral blocks from the reef and branches and fragments are further broken down the same processes. Calcareous red algae may be closely inter-grown with coral and therefore difficult to distinguish from it. As a result, coral and calcareous red algae are put together in a single category.

3.5.2 Summary of aggregate extraction sites and known resources

Current aggregate extraction sites, sourcing, and potential lagoonal resources

Sourcing construction aggregates in atoll nations with limited geological resources presents several challenges related to the quality and quantity of local resources, social and environmental impacts of extraction activities, and elevated costs when aggregates are to be externally sourced. In general, aggregates in atoll countries like the RMI are limited to sand, gravel, and stone in lagoons and on beaches. Coral is also known to be extracted directly from reefs on occasion (Figure 46).

[156] Xue, C. (1997). Coastal Sedimentation Erosion and Management of Majuro Atoll, Republic of Marshall Islands. *SOPAC Technical Report* 254.

[157] Krüger, J. and Kumar, S. (2008) Marshall Islands, High Resolution Bathymetry Survey. *SOPAC Secretariat Technical Report* ER117.

[158] Emery K.O., Tracey, J.I., Jr., and Ladd, H.S. (1954). Geology of Bikini and Nearby Atolls. *United States Geological Survey Professional Paper* 260-A.

[159] McLean, R.F. and Woodroffe, C.D. (1994). Coral Atolls. In Carter, R.W.G., Woodroffe, C.D. (Eds.), *Coastal Evolution: Late Quaternary Shoreline Morphodynamics*. Cambridge: Cambridge Univ. Press, pp. 267–302; Woodroffe, C.D. and Biribo, N. (2011). Atolls. In D. Hopley (ed.), *Encyclopedia of Modern Coral Reefs: Structure, Form and Process* (pp. 51–71). The Netherlands: Springer. https://ro.uow.edu.au/scipapers/1060.

[160] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

Figure 46: Reef Aggregate Extraction Site in the Marshall Islands

Photo credit: Robert Smith n.d.

An additional challenge facing the RMI is UXO. The country has numerous unexploded munitions from World War II that are scattered throughout its 29 atolls and have remained for the most part untouched. It has been estimated that 10% of the ordnance fired or dropped did not detonate and, in the case of the bombardments of Milli Atoll, 50%–60% of the ordnance fired did not detonate. Despite the close proximity to residential areas, people have gotten used to living and working next to this ordnance and it has become a part of their daily life. However, they do present major risks for aggregate extraction operations in lagoons and coastal zones; detailed inspections of resource areas and construction sites should be undertaken during the design stage and, ideally, when topographical surveys and geotechnical investigations are undertaken. For example, in Tuvalu, the EIA procedures require the ordnance to be magnetically surveyed prior to activities. Finally, there is also the issue of the contamination of marine sediments from this ordnance, with both Majuro and Ebeye at particular risk.

Aggregate importation

With no hard rock resources, the RMI have had to import aggregate from other countries in the region. For instance, armor rock was initially imported to Majuro from Nauru in 2015, at $45.0 free-on-board Nauru per metric ton and aggregate with a 100–300 mm dimension at $60 per ton. However, barge-landing and material-handling difficulties necessitated the change to a local supply of aggregate from the ocean side of Majuro.[161]

In Kwajalein, limestone-based rock and aggregate has been sourced from Smithbridge's quarry in Guam and transported on 2,000-ton or 7,000-ton barges. Rock density from this source was 2.5 to 2.7 t/m^3. Interest in supply of armor rock from Pohnpei has also been explored but requires further

[161] Hill, B. (2017). RMI Construction Risk Review for Ebeye Coastal Protection Project. Bond Construction Management Limited.

investigation. Aggregate is reportedly being imported from Hawaii for construction projects for US military infrastructure.[162] Vanuatu has also been identified as a source for aggregate, which has reportedly exported via barge large quantities of basalt and limestone rock for an unspecified major roading project.[163] Armor rock with densities from 2.4–2.5 t/m^3 from Fiji has also been explored.

Aggregate extraction in Majuro Atoll

Prior to 1994, no significant sedimentary data were available for Majuro lagoon. Subsequent studies involved limited echo-sounder mapping and sampling, followed by more comprehensive bathymetric mapping using high-resolution multibeam techniques, along with sampling and seismic profiling.[164] In 2004, approximately 80% of the inner margin of Majuro Lagoon covering 478 km was surveyed using high-resolution multibeam mapping to identify areas likely to have sediment accumulations in the form of terraces, tidal, or channel fans, shallow banks, and shelf areas.[165] The survey also examined accumulations similar to talus deposits occurring on or near the bases of steep slopes and large coral patches. Efforts are also currently underway through the World Bank-funded, SPC-led PREP II project to identify sustainable sources of aggregate for construction. It should be noted that the World Bank maintains a ban of sourcing of aggregates from beaches and lagoons due to adverse environmental impacts, which will presumably be avoided in future extraction based on the findings of PREP II. As with any marine sediment, the aggregate must be washed to remove salt before being used, particularly in concrete applications. This can present a challenge in atoll contexts which, due to their geology, are water-constrained.

As the capital of RMI, over the years, Majuro has experienced unprecedented extraction of aggregates from about 30 sites in the lagoon and ocean reef flat for infrastructure and ad hoc reclamation projects. Much of the extraction has occurred in the east of Majuro lagoon with extraction concentrated in the nearshore areas off DUD, Rairok east, and west of the international airport in Rairok west (Figure 47).[166]

An alternative to the present sites may be to source from new sites along the northern rim of Majuro lagoon. These sites have the potential to provide a sustainable supply of marine sand and gravel aggregates given they have the necessary attributes for sediment generation at the reef platform, specifically, clear pathways to sediment sinks located on the inner margin slopes of the lagoon.[167]

[162] Personal communication, donor representative. Dated 14/12/2023.

[163] Hill, B. (2017). RMI Construction Risk Review for Ebeye Coastal Protection Project. Bond Construction Management Limited.

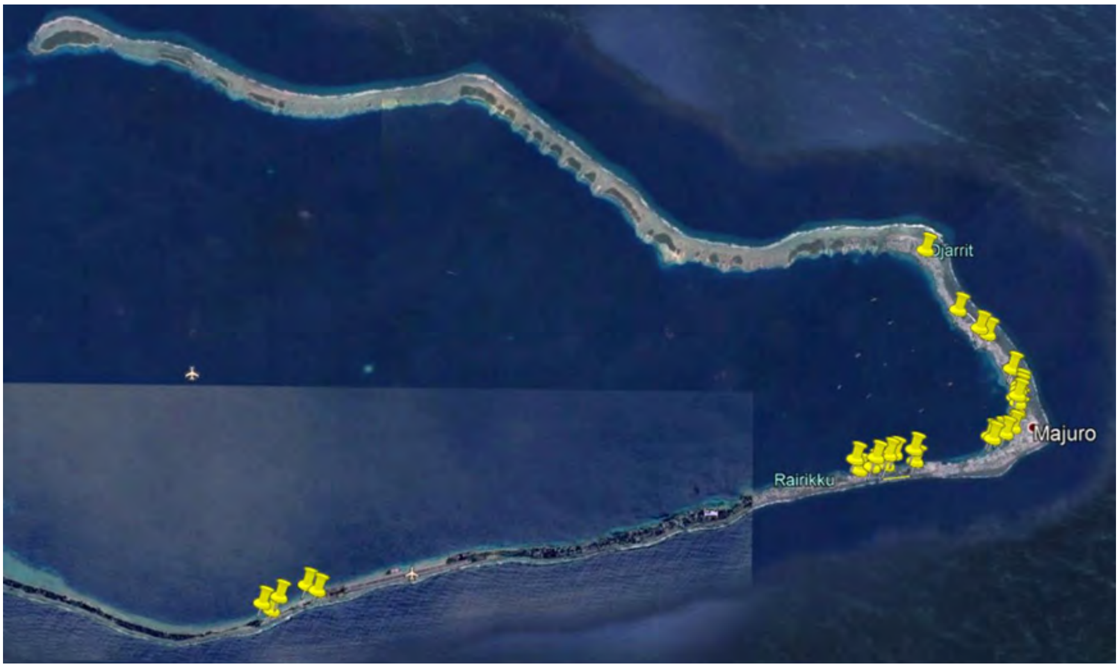
[164] Smith, R., Young, S., and Frost, G. (1994). Survey for Alternative Sand and Gravel Resources, Majuro Atoll, Marshall Islands, March, April 1994. *SOPAC Preliminary Report* 71: 16 p.; figs., 2 app. Funded by: European Union; Government of Australia.

[165] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

[166] Smith, R. (2021). Inception Report for Aggregate Resource Evaluation Surveys for Majuro and Ebeye Island, Kwajalein Atoll Republic of The Marshall Islands. Smith Geoscience Consultancy, Suva Fiji.

[167] An excellent summary of extraction areas up to 2023 is provided in Smith (2023; in draft).

Figure 47: 2019 Google Earth Image Illustrating Sites Where Extraction for Aggregates Has Been Concentrated in the Nearshore Lagoon and Ocean Reef Flat of Eastern Majuro Atoll



Source: Smith, 2021

Ebeye in Kwajalein Atoll

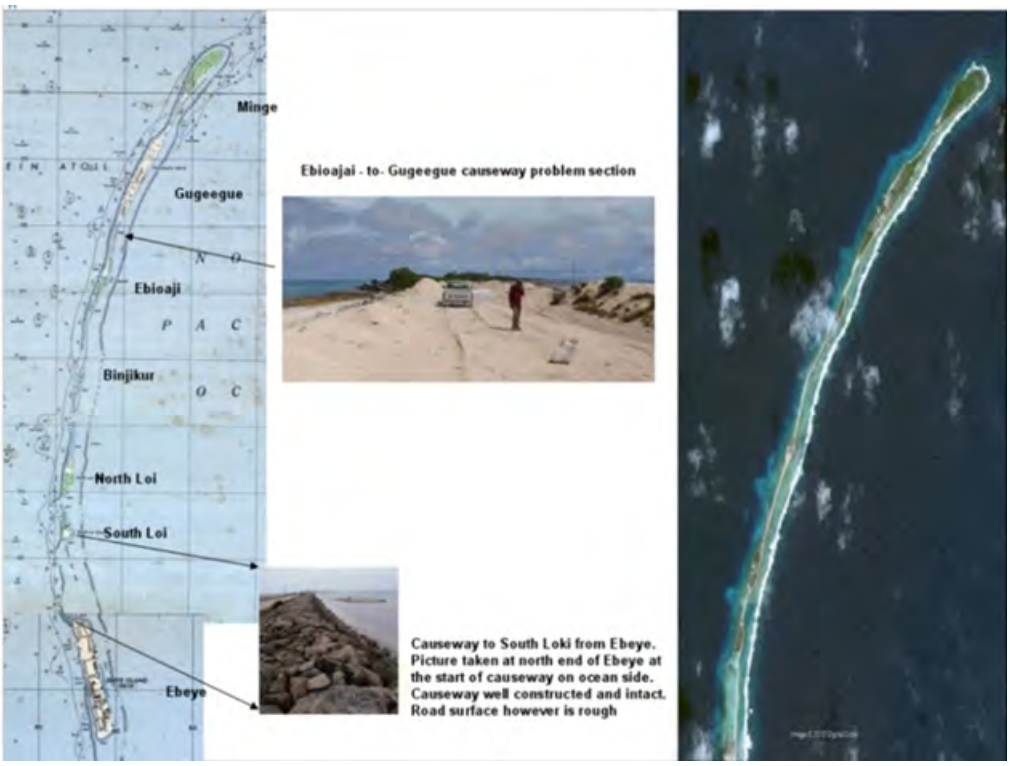
Ebeye is located on a small islet on the southeastern side of Kwajalein Atoll (8.78° N, 167.74° E), stretching about 2 km from north to south and approximately 250 m wide bordering a large lagoon to the east and the open ocean to the west. The islet is covered entirely with buildings and infrastructure and is densely populated, with around 12,000 inhabitants living in an area of only 0.36 km^2, resulting in a population density of one person per 30 m^2. [168]

In addition to Ebeye, there is a chain of six smaller islets linked by reef flat causeways initially constructed by the US Army Corps of Engineers (Figure 48).[169] Armor rock for the causeway was sourced from borrow pits on the ocean side reef, while causeway fill was sourced from the lagoon-side reef flat using draglines and excavators. Estimates of fill material were 181,000 m^3, comprising coralline sand and rubble and 79,727 m^3 of stone sourced from 165,919 m^2 of reef flat dredged to a depth of 1.5 m. An estimated area of 35,612 m^2 of lagoon shoals dredged to a depth of 3 m was the intended source for roadway and causeway core.

[168] Giardino, A., Nederhoff, K., Gawehn, M., Quataert, E., and Capel, A. (2017). Coastal Risk Assessment for Ebeye. *World Bank Group Technical Report*. https://www.gfdrr.org/sites/default/files/publication/Coastal_risk_assessment_Ebeye_1.pdf. Accessed 20/12/2023.

[169] US Army Corps of Engineers (1986). Final Environmental Impact Statement US Department of the Army Permit Application Discharge of Fill Material for the Kwajalein Atoll Causeway Project, Kwajalein Atoll, Republic of the Marshall Islands. US Army Corps of Engineers Honolulu District. 256 pp. https://apps.dtic.mil/sti/tr/pdf/ADA209676.pdf. Accessed 20/12/2023.

Figure 48: Left - sketch map showing the original six islands to be linked by causeways. Right - satellite image showing the island linked by causeway from Google Earth.

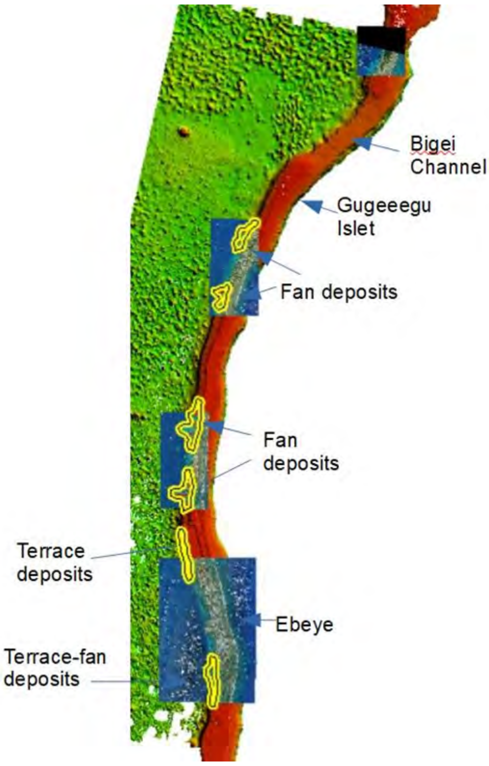


Source: Smith 2013[170]

Future aggregates resources being investigated are shown in Figure 49.

[170] Smith R. (2013). Coastal Erosion Assessment, Ebeye, Kwajalein Atoll, Marshall Islands. SOPAC Technical REPORT (PR150). Suva, Fiji.

Figure 49: Sketch Map Illustrating Potential Resources Areas for Survey, Ebeye



Source: Smith, 2021

3.5.3 Aggregates required for national infrastructure development

Infrastructure is one of the five pillars of the RMI National Strategic Plan (NSP) 2020–2030.[171] The infrastructure pillar encompasses six key infrastructure areas such as transport, energy, water and sanitation, waste management, and public facilities. The overarching objective of the infrastructure pillar is to "provide efficient, effective, resilient, sustainable, and affordable services and facilities that promote sustainable economic growth."[172]

PRIF's project pipeline report identifies projects in four sectors with a cost of $52.86 million, each with varying predicted aggregate requirements, as estimated based on type of project and, where available, project documents (Table 19). While these aggregate requirements are not at the same level of countries such as Fiji, they are still challenging to meet given that, other than lagoon aggregates, the RMI does not have other resources of the right kind and of sufficient quality to meet all infrastructure demands. With climate change, it is also likely that there will be future demands for additional armor rock, which are currently brought in from countries such as Fiji and Guam, though imports from outside of the region may also be needed. The need for coastal protection around Ebeye is, in particular, critical because of its small size, high population density, and exposure of critical infrastructure to wave action, with little option of retreating due to constrained land availability (Figure 50).

[171] NSP is the RMI's strategic plan regarding national social, cultural, and economic development priorities, and it is aligned with the UN Sustainable Development Goals.

[172] Republic of the Marshall Islands National Strategic Plan 2020–2030. www.theprif.org/sites/default/files/2020-08/Marshall%20Islands%20National%20Strategic%20Plan%202020%20to%202030.pdf. Accessed 07/12/2023.

Table 19: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for the Marshall Islands and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Majuro Airport Terminal	32.0	Very High	Requires very high volume of aggregates for concrete, asphalt, and pavement layers and roads, hangers, runways, taxiways, aprons etc. (dependent on design and specifications)
Energy	Electrification Project- Phase 2	10.0	low	Requires a low quantity of aggregates for concrete poles (based on the design), powerhouse and supply station(s).
Water and sanitation/urban development	Integrated Urban Services Improvement Project	52.5	High	May require large volumes of aggregate for construction of water infrastructure, buildings etc. depending on project specs
Water and sanitation	Water and sewer project	10.86 (TA)	Moderate	This is a technical assistance project. However, the actual implementation might require a moderate amount of aggregates concrete, and sand for water treatment. Likely to involve the construction of reservoirs, pumping stations, treatment plants, and pipelines among others.
Fisheries Infrastructure	Transaction advisory support for fisheries dock infrastructure	TBD	Low	Might require a low volume of aggregates if support structures for the fisheries dock project are included.
Total ($)		**52.86 million**		

TA = technical assistance, TBD = to be determined.

Source: PRIF, 2023; relevant project reports where available

Figure 50: Armor Rock for Coastal Protection in Majuro, the Marshall Islands

Photo credit: Robert Smith n.d.

3.5.4 Overview of the legal and policy framework

Land and resource ownership

The rights to nearshore resources in RMI are outlined in the Public Lands and Resources Act Title 9 – Public Lands and Resources 1966. The act states that all marine areas below the ordinary high watermark belong to the government. This is a law that was established during the Japanese administration of RMI; however, the act also defines exceptions pertaining to people owning land abutting the coast and their customary rights. Coastal landowners have the right to erect and manage fish weirs or traps, fish in waters over reefs where the general depth does not exceed four feet, claim ownership of materials and small objects deposited on the shore, and erect structures approved by the Chief Secretary in the marine area abutting their property.

With respect to marine resources, the Constitution of the Marshall Islands of 1979 states that internal lagoon waters and the sea out to five miles from the baselines from which the territorial sea of that atoll or island is measured are under jurisdiction of the local government. While the local governments have the right to pass ordinances within these marine areas, they are still bound by the laws of the RMI government.

The public entity that can legally regulate the RMI marine resources is the Marshall Islands Marine Resources Authority, according to the Marshall Islands Marine Resources Act 1993. In order to extract resources from these marine areas, licenses must be acquired from the relevant authority. These resources are regulated under the Marshall Islands Marine Resources Act 1993, Fishing License (Third Implementation Agreement) Regulation 2009, Sea Cucumber Regulations of 2012, and Aquarium Fisheries Regulations of 2015. Although there are no formal royalty regimes for aggregate resources in RMI, a de facto system exists in the form of payments required by landowners for the storage of materials extracted from the marine environment. This is because there is no government land in RMI with all land privately held.[173]

Coast Conservation Act 1988

This act provides for a survey of the coastal zone and the preparation of a coastal zone management plan, and also regulates development activities within the coastal zone, which is demarcated as the area extending 25 feet landwards from the high-water line and 200 feet seawards of the mean low-water line. "Development activity" refers to an activity that alters the coastal zone such as construction of buildings, deposit of wastes, the "removal of sand, coral, shells, natural vegetation, sea grass or other substances, dredging and filling, land reclamation and mining or drilling for minerals…." The act also empowers the Director of Coast Conservation within the EPA to require the submission of an EIA when submitting a permit for development activity.

Marshall Islands Marine Resources Act 1997

This act provides for the management, conservation, and development of fisheries resources of the RMI and the development of the fisheries industry. It also establishes the Marshall Islands Marine Resources Authority.

Marshall Islands Maritime Zones (Declaration Act (2016

This act deals with the RMI's maritime zones, including defining the boundaries of and jurisdiction within those zones, such as its Territorial Sea, Archipelagic Waters, Continental Shelf, and Exclusive Economic Zone (EEZ). Within the EEZ and Continental Shelf, the act declares the country's sovereign rights over natural resources, whether living or non-living, encompassing the seabed; the

[173] Personal communication, donor representative. Dated 14/12/2024.

subsoil under the seabed; and the waters over the seabed. It also provides for the right to protect the marine environment, including conservation and management, through “rules, regulations, methods and measures” necessary to build and protect fishery resources and the marine environment.[174]

National Environmental Protection Act (Title 35)

This National Environmental Protection Act (NEPA) provides a framework for national environment protection policy and environment protection measures. It also establishes the National Environmental Protection Authority. The 66 sections of the act deal with, among other things, the duties, policies, powers and functions of the Authority, the establishment of an Environmental Advisory Council, and enforcement of rules and regulations pertaining to the environment. The act also outlines the expectations and actions required by government ministries, departments, and agencies with regard to the conduct of environmental impact assessment and development of environmental impact statements.[175]

Protected Areas Network Act 2015 (P.L. 2015-48)

This act provides for a Protected Areas Network, wherein “Protected Area” means an area designated for protection through the Ministry of Resources and Development, which is responsible for its administration. The ministry also has a Protected Areas Network Office. Management of the network is to be undertaken by Local Resources Committees and advice provided by a Technical Advisory Committee. Where possible and where desired by a local community, each Protected Areas Network is to have a Local Resources Committee.

The act divides protected areas into two types: the first is for subsistence only with limited commercial use, provided there are no associated environmental impacts on habitat quality. The second is subject to “no-take” or a very low level of subsistence or special occasion activities with no commercial use. The act also outlines provisions for enforcement and defines offences, as well as the powers of the Ministry of Resources and Development to make regulation.

Policies

Earthmoving Regulations 1989 (Incorporating 1994 Amendments)

Dredging of marine sediments in the RMI is regulated under the Earthmoving Regulations 1989 (amended 1994), which are promulgated by the RMI EPA under the NEPA. The regulations define earthmoving to include “any construction or other activity which disturbs or alters the surface of the land, a coral reef or bottom of a lagoon, including, but not limited to, excavations, dredging, embankments, land reclamation in a lagoon, land development, subdivision development, mineral extraction, ocean disposal, and the moving, depositing or storing of soil, rock, coral, or earth.” The purpose of the regulations is to ensure that earthmoving is conducted a way that prevents accelerated erosion and sedimentation and disturbance of potential cultural resources.

In order to engage in earthmoving activities such as dredging the lagoon for aggregates, proponents are required to submit an Earthmoving Permit Application to the EPA. The application requires proponents to outline what the foreseeable impacts of the activity will be and to state what mitigation measures will be put in place. Application fees are calculated as a percentage of the project’s total

[174] Food and Agriculture Organization of the United Nations. Marshall Islands Maritime Zones (Declaration) Act 1984. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC158412. Accessed 13/12/2023.

[175] Food and Agriculture Organization of the United Nations. Marshall Islands National Environmental Protection Act. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC049860. Accessed 14/12/2023.

budget, with projects less than $100,000 paying 1% (but a minimum fee of $100) and projects valued at $201,000 or greater paying 0.5%, with a maximum fee of $5,000.[176]

Environmental Impact Assessment Regulations 1994

These Regulations are implemented by the RMI EPA under the NEPA (Part IV) and section 11 of the Coast Conservation Act. They establish standard procedures for the preparation and evaluation of environmental impact assessments for both public and private development activities that may affect the environment. The Regulations establish uniform standards under the two Acts so that environmental scrutiny of proposed development activities may be streamlined and simplified. The regulations are aimed at integrating the EIA process into the early planning of projects to identify at an early stage any significant environmental impacts development activities may have.

Project proponents are first required submit a Preliminary Proposal, now called a Preliminary Environmental Assessment (PEA)[177] to the Coastal, Land and Conservation Division of the EPA, which determines the significance of any environmental impacts. Based a review of this document, and any other relevant data, either the EPA's General Manager or Director of Coast Conservation will determine if a full EIA is required.[178]

Marshall Islands Marine Resources Authority Strategic Plan 2019-2023

The Marshall Islands Marine Resources Authority (MIMRA) Strategic Plan describes the actions required to enable the sustainable and responsible use of marine resources. This is to be achieved by improving the economic benefits from the fisheries sector within sustainable limits, promoting private sector led fishery developments, and strengthening institutional capacity to responsibly develop and manage the country's fisheries resources. MIMRA's strategic goals are to: (I) maximize the long-term value from fisheries for the benefit of the RMI people; (II) conserve and manage aquatic resources for current and future generations; and (III) to enable professional, transparent, and accountable management of fisheries resources.[179]

Sustainable Development Regulations 2006

The Sustainable Development Regulations are promulgated by the EPA pursuant Sections 3 and 27 of the Coast Conservation Act 1988 and Section 21 of the National Environmental Protection Act 1984. The purpose of the regulations is to implement the Coast Conservation Act and NEPA by establishing standards, criteria, and permitting procedures, including environmental permits, for

[176] Republic of the Marshall Islands Environmental Protection Authority. Earthmoving Permit Application. On file with authors.

[177] Food and Agriculture Organization of the United Nations. Environmental Impact Assessment Regulations 1994. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC099536. Accessed 14/12/2023. See also Centralized Implementation Unit of the RMI Division of Development Assistance (DIDA) (2022). Republic of the Marshall Islands, Pacific Islands Regional Oceanscape Program for Economic Recovery and Resilience (PROPER) Project, Environmental and Social Management Plan. https://www.rmimimra.com/media/attachments/2022/11/17/environmental-social-management-plan-esmp-rmi-proper.pdf. Accessed 13/08/2024.

[178] Food and Agriculture Organization of the United Nations. Environmental Impact Assessment Regulations 1994. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC099536. Accessed 14/12/2023.

[179] Food and Agriculture Organization of the United Nations. Marshall Islands Marine Resources Authority Strategic Plan 2019–2023. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC219815. Accessed 14/12/2023.

development activity to ensure the sustainable development and preservation of the RMI natural resources.[180]

The criteria outlined in the regulations to determine which development activities would require a Development Activity Permit included prohibitions on mining operations and removal of sand from the lagoon at a depth of less than 30 feet below the mean low water line (with the exception of maintenance dredging for navigational channels and seaports); removal of sand from behind beach rock near the coastline for commercial purposes; and any open blasting within the lagoon. These criteria were established by regulation prior to the coming into operation of the Coast Conservation Act's proposed Coastal Zone Management Plan, though no such plan has implemented and it is not known if the sustainable development regulations are still valid.

2050 Climate Strategy

This 2050 Climate Strategy provides a framework for the RMI to work towards net zero greenhouse gas emissions by 2050. It outlines a pathway for achieving low greenhouse gas emissions and climate resilience. The strategy includes actions for having 100% renewable energy, as well as measures to facilitate adaptation and climate resilience in a way that ensures the future protection and prosperity of the country and its people.

3.5.5 The institutional and operating context

Ministry of Environment

Formerly part of the Ministry of Environment and Health, the Ministry of Environment was established as its own entity in 2018 with the introduction of the Ministry of Environment Act 2018. The Ministry's primary role is to enhance and strengthen collaboration and coordination for environmental protection, restoration, and conservation. Its mandate includes promoting the sustainable use of natural and genetic resources, use of sustainable energy, and mitigation and adaptation to climate change impacts and natural hazards.[181] The act established four entities under the Ministry the Environmental Protection Authority, Climate Change Directorate, the National Energy Office, and National Council on the Environment.

Environmental Protection Authority

Established in 1984 the Marshall Islands Environmental Protection Authority (EPA) is responsible for preserving and improving the quality of RMI's environment.[182] The EPA is a government funded statutory authority and the country's primary agency for environmental protection. In addition to being responsible for issuing permits to undertake dredging activities, as regulated under the Earthmoving Regulations, the EPA is also responsible for nature conservation, waste disposal, public sanitation, water quality monitoring and environmental education.

Marshall Islands Marine Resources Authority

MIMRA is an independent authority that is responsible for regulating the RMI inshore coastal resources and offshore fishery resources within the country's 200-nautical mile EEZ. It also regulates RMI-flagged vessels fishing outside its EEZ. MIMRA's mission is to facilitate the sustainable and

[180] Food and Agriculture Organization of the United Nations. Sustainable Development Regulations 2006. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC202021. Accessed 14/12/2023.

[181] Environmental Protection Act 2018. https://rmiparliament.org/cms/images/LEGISLATION/PRINCIPAL/2019/2019-0108/MinistryofEnvironmentAct2018_1.pdf. Accessed 17/12/2023.

[182] Republic of the Marshall Islands Environment Data Portal. https://rmi-data.sprep.org/group/1. Accessed 17/12/2023

responsible use of marine resources in order to enhance the economic benefits from the fisheries sector, promote sustainable private sector-led development of the fisheries industry, and strengthen the capacity of institutions to responsibly develop and manage RMI's fisheries resources.[183] MIMRA has four Divisions: 1) Coastal and Community Affairs; 2) Oceanic and Industrial Affairs; 3) Finance and Corporate Affairs; 3) Legal Affairs. It also has a "Competent Authority" whose responsibility is to provide the regulatory framework for the fisheries industry.

Ministry of Resources and Development

The Ministry of Resources and Development is the government ministry responsible for agriculture, energy and trade and investment. Its mission is to support the sustainable development of these sectors. Key focus issues of the Ministry include fostering sustainable food production, alternative energy resources and alternative income generating opportunities for RMI's people. The Ministry has a special focus on developing agricultural, energy and economic sectors outer-island communities.[184]

Ministry of Works, Infrastructure and Utilities

The Ministry of Works, Infrastructure and Utilities is the government department responsible for the planning, development, and maintenance of public infrastructure, such as roads, bridges, buildings, and other physical infrastructure. Its primary purpose is to ensure that RMI's infrastructure is in good condition and able to meet the needs of the people and the country.[185]

The Ministry reportedly is in the formation stages of developing an RMI Building Code based on the Yap Building Code model.

3.6 Nauru

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Nauru	**Low** "Priority" projects from Nauru's Integrated Infrastructure Strategic Plan 2019–2030 estimated to cost around $68.79 million.	- Dolomite / limestone	**Medium to High** 2020–2022 imports: ~12.5 tons 2020–2022 exports: 0 tons Nauru has a substantial dolomite reserve that should theoretically be able to fulfill all or most coarse aggregate needs over the coming years (and, if managed properly could be a source of exports). Minor quantities of sand imports (~12.5 tons) over past 3 years indicate it may require continued

[183] Food and Agriculture Organization of the United Nations. Marshall Islands Marine Resources Authority Strategic Plan 2019–2023. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC219815. Accessed 12/12/2023.
[184] Republic of the Marshall Islands, Ministry of Resources and Development. (2016). Outer Islands Electrification Strategy. https://prdrse4all.spc.int/content/rmi-ministry-resources-development. Accessed 17/12/2023.
[185] See the Pacific Resilience Program Phase 2 (PREP II) https://prepii.org/rmi-agencies/.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			imports of sand / gravel in coming years.

3.6.1 Geography and geology

Nauru is a small island country covering a land area of 22 km^2 lying 59 km south of the equator in the western Pacific (Figure 51). The island is a raised atoll with land elevation up to 70 m above sea level. Nauru played a significant role in the economic and social development of neighboring countries such as New Zealand and Australia. Rock phosphate (guano), once the most abundant mineral in Nauru, was mined to supply Australia and New Zealand's important agricultural sectors. By the late 20th century, most of the phosphate that covered the island was mined out, exposing a barren and dry landscape of dolomite pinnacles (Figure 52).[186]

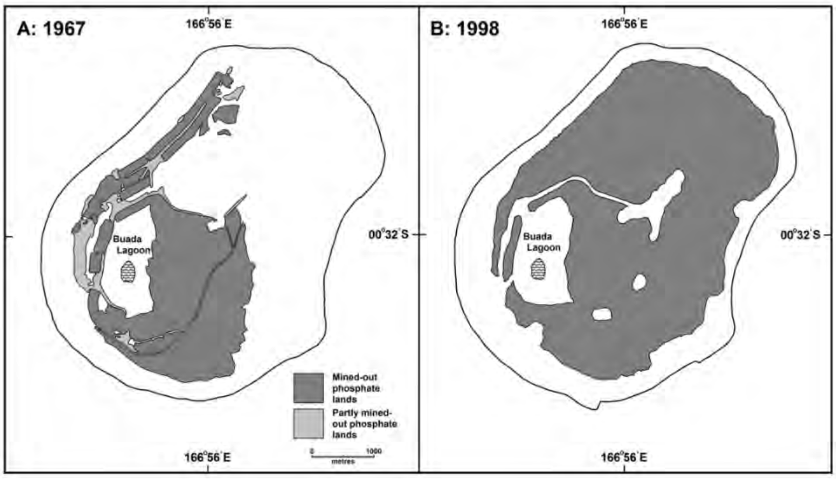
Figure 51: Location Map of Nauru

Source: Britanica.com

The island is composed almost entirely of dolomite limestone of post-Middle Miocene age. Prior to phosphate mining, the dolomite was almost entirely covered by a layer of phosphate of up to 24 m deep, which was deposited 0.22 to 0.08 Ma ago (Figure 53). The only exposed bedrock occurred along the coastal terrace, along the fringing limestone cliffs and where occasional pinnacles of limestone protruded through the overburden.

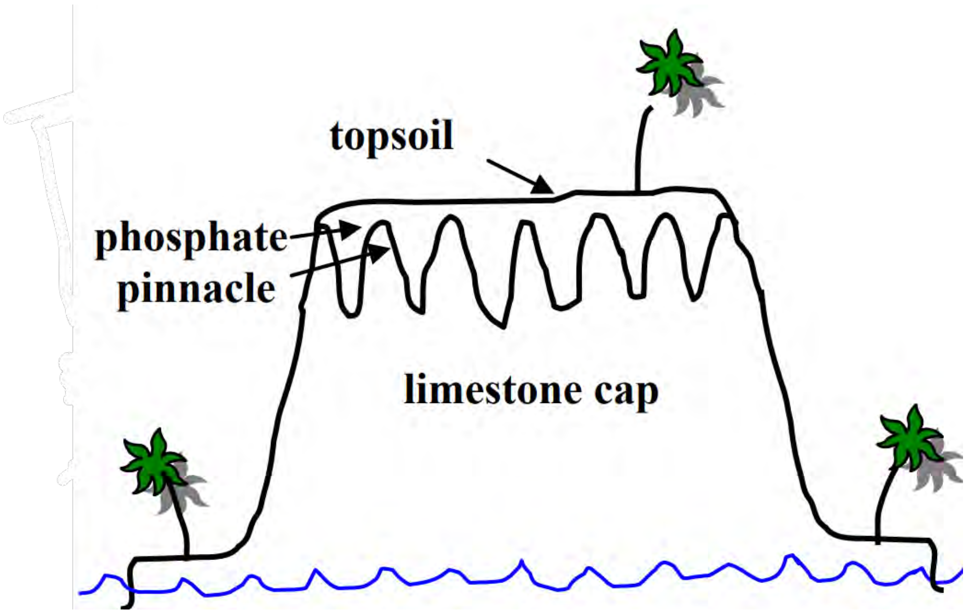
[186] Gale, S.J. (2019). Lies and Misdemeanours: Nauru, Phosphate and Global Geopolitics. *The Extractive Industries and Society*, 6(3), pp.737–746.

Figure 52: The Mined-Out Phosphate Lands of Nauru in July 1967 and in 1998, by Which Time Most of the Primary Reserves Had Been Exhausted



Source: Gale 2019

Figure 53: Geological Structure of Nauru's Limestone and Phosphate Deposition



Source: Davis, J. W. (2010). The Feasibility of a Nauruan Limestone Industry and its Linkage with Rehabilitation. Boulder: The Environmental Studies Institute.

3.6.2 Summary of aggregate extraction sites and known resources

The dolomite pinnacle fields leftover from the phosphate mining comprise 1,500 ha, or 68.1% of Nauru's land area.[187] The pinnacles are categorized based on size, thickness of the ridges, and the width of interstices or troughs between the ridges (Table 20). Pinnacles could also be categorized as

[187] Davis, J. W. (2010). *The Feasibility of a Nauruan Limestone Industry and its Linkage with Rehabilitation*. Boulder: The Environmental Studies Institute.

primary (above ground) and secondary (from the level reached by primary phosphate mining to the fused base) and underlying solid cap limestone.

A feasibility report estimated there are around 250 pinnacles per hectare in Nauru.[188] Assuming there are 1,700 ha of mined-out areas, the total volume of primary pinnacle stone would be 5,525,000 m^3. Meanwhile, the volume of secondary pinnacles was estimated to be 24,934,495 m^3 based on the assumption that the height of the pinnacles is around 8.3 m. Further, the volume of cap limestone, assuming a mean island elevation of 40 m, is 680 million m^3. It is also assumed that the deeper limestone is denser and of higher quality.

These categorizations are important when considering the feasibility and sustainability of a limestone industry in Nauru. Quarrying the primary and secondary pinnacles could provide both Nauru and other PICs with aggregate resources for a significant period, given the estimated dolomite reserves. The dolomite boulders could be used as dimension stone, tiles, bricks and columns for construction, cement, and concrete, and as aggregate for road construction and armor rock. Different classes of pinnacles could be suitable for different usage. Class I, for example, are denser than Class II and II pinnacles, and which can be used in structural concrete, sealing chip and so on.

Currently, there is one active quarry in Nauru operated by the NRC (Figure 54). The phosphate industry is maintained and operated by the Republic of Nauru Phosphate Corporation (RONPHOS), which is engaged in secondary phosphate mining. RONPHOS reports that it is also investigating the possibility of exporting limestone however, there has reportedly been a recent ruling by the Nauru government that affirmed NRC's rights as the sole body responsible for dolomite extraction and export.

Table 20: Classification of the Pinnacle Type Based on Characteristics Such as Size, Thickness of the Ridges, and the Width of Interstices or Troughs between the Ridges

Pinnacle Field Class	Prominent Organizational Features	Ridge, Trough, and Pinnacle Size	Location on Nauru Islands	Estimated coverage of Nauru Islands
Class I	Interconnected ridges of pinnacles, occasional linear arrays	Large: 2.5–6.0 m thick, up to 100 + m long, narrow troughs between ridges (1–5 m) that may be deep	Eastern coastal plateau and high topside elevations, eastern beaches	16.4%
Class II	Weak ridge structure and some ring arrays, more extensive linear arrays	Medium: 1–3 m thick, up to 50 m long, wider troughs between ridges (2–10 m) but perhaps shallower	Eastern coastal plateau and high topside elevations, eastern beaches	72.1%
Class III	Random, no ridges, no linear arrays, rings and individual pinnacles	Small: 0.5–2.0 m thick, no ridges or coherent troughs, random distribution	Southwestern topside, northwestern beaches, low inland elevations	2.9%

Source: Davis 2010

188 Ibid.

Figure 54: Limestone Quarry in Nauru Operated by NRC

Photo credit: Robert Smith n.d.

3.6.3 Aggregates required for national infrastructure development

In 2019, the Nauru Cabinet endorsed and launched its Integrated Infrastructure Strategic Plan 2019–2030, covering a variety of infrastructure valued at $213.97.[189] The plan covers roads, ports, water and sanitation, and energy, among others; however, only a subset of 53 projects have been identified at “Priority Projects” and are estimated to cost around $73 million) over the 10-year period. Of these, the top 10 prioritized projects are of a modest nature and encompass renovations to medical facilities, schools, government buildings, construction of a new nursing home, and other projects. If these projects go ahead, they will require a moderate amount of aggregate, which, given Nauru’s limestone / dolomite resources, the country should be able to supply, provided the right technical and operational support is in place. Whether this will be the case, however, depends on the ability of government, NRC, and donors to make sure there is capacity to efficiently ramp up production.

Meanwhile, PRIF members have identified three key projects, as shown in Table 21, which should be well serviced by existing aggregate resources.

[189] Converted from Australian dollars using 2019 average conversion rate of A$1 = $0.695.

Table 21: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for Nauru and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Urban development	Nauru Sustainable Urban Development Project	25.0	Medium	May require a relatively moderate quantity of aggregates given modest budget. Project details unknown but is likely to include building and road construction and renovation, requiring aggregates for road base, chip, and concrete.
ICT	Nauru e-Government project	10.0 (TA only)	NA-low	Unlikely to require any aggregate given the project is technical advisory only.
ICT	East Micronesia Cable - FSM, Kiribati, Nauru (w/Japan, Australia and US)	25	TBC	Details of project not available but unlikely to use very large amounts of aggregate given nature of project. Also, aggregate requirements, if they exist, are likely to be met by all countries involved in the project.
Total ($)		**60.0 M**		

FSM = Federated States of Micronesia, ICT = information and communications technology, TA = technical assistance, TBC = to be calculated.

Source: PRIF, 2023

3.6.4 Overview of the legal and policy framework

Land and resource ownership

All land in Nauru is customary land. Government and private entities cannot own land and they must enter into leasing agreements with the landowners. Unlike other PICs, the land is not managed by customary chiefs. Instead, a Land Committee is appointed by the Cabinet.

Lands Act 1976

This act provides for the leasing of land for purposes such as the phosphate industry, removal of trees, soil, sand and coral/limestone, and payment of royalties or compensation for each of these activities.[190] According to the act, land can be leased only if three-quarters of the landowners sign the lease agreement, and it is endorsed by a Cabinet member. The act also establishes the amounts of royalties that should be paid for sand, coral, and limestone. The rates were last updated in 1974 when they were A$0.74 per ton. It is not clear if this has been updated since.

[190] Land Act 176. http://ronlaw.gov.nr/nauru_lpms/files/acts/e65482789af1dcc78723116e66758ec9.pdf. Accessed on 27/09/2023.

Land (Declaration of Ownership) Ordinance 1962

This ordinance was established to provide for the compensation of landowners who were not compensated from the phosphate mining operations from the German Wireless Station land area.[191]

Land Committee Act 1956

This act provides for the establishment of the Nauru Land Committee which manages and deals with issues relating to land ownership and rights.[192]

Policies

Environmental Management and Climate Change Act 2020

This is the main legislation that provides for the establishment of the EIA Committee and sets out the EIA process required for developers.[193] Any individual who intends to undertake a development project must apply for an approval to the Secretary of the Committee. Depending on the type of project the Secretary will decide whether an EIA is required. According to the act, activities that are considered substantial projects include: sand or gravel extraction from any beach within 50 m of the high tide mark or any other development project as prescribed by the Cabinet. The EIA must include all environmental impacts that the project is likely to cause, the environmental management plan to monitor and mitigate these impacts, and a waste and pollution and management plan. Finally, the Committee conducts all necessary consultations with stakeholders impacted by the project before granting the approval.

Nauru National Sustainable Development Strategy (NSDS) 2019–2030

The NSDS is a policy document that aims to develop Nauru's economy through the improvement of national governance, the economy, education, health and well-being, infrastructure, and resilience against the impacts of climate change.[194] In the early 2000s, almost all phosphate mining operations ceased which led to the need to diversify the "economy sector" (Priority Area 1). Goal 4 of the Priority Area 1 focuses on the need to efficiently and effectively use the mining and quarrying sector for the rehabilitation of the economic sector. Priority Area 4 (Cross-cutting Sectors), states the need for sustainable use and management of the environment and natural resources. Priority Area 3: Infrastructure indicates the need for providing reliable transport, energy and water supply and sanitation infrastructure.

[191] Land (Declaration of Ownership) Ordinance 1962. http://ronlaw.gov.nr/nauru_lpms/index.php/act/view/710. Accessed 27/09/2023.

[192] Land Committee Act 1956. http://ronlaw.gov.nr/nauru_lpms/files/acts/2c846e3c2ee971e08714963cf017f459.pdf. Accessed on 27/09/2023.

[193] Food and Agriculture Organization of the United Nations. Environmental Management and Climate Change Act 2020. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC202024/. Accessed 27/09/2023.

[194] Nauru's National Sustainable Development Strategy 2019–2030. https://naurufinance.info/wp-content/uploads/2020/07/Final-NSDS-2019-2030.pdf. Accessed 28/09/2023.

Nauru Rehabilitation Corporation Act 1997

This act establishes NRC, whose main aim is to carry out projects for the rehabilitation of the lands where phosphate was extracted.[195]

Explosives Act 1924

This act regulates the import, use for blasting purposes and storage of explosives.[196]

Nauru Roads Act 2017

This gives the relevant Ministry and Department the authority to enter land if required for construction or repairing public roads.[197] Unlike the Roads Act in Fiji, there is no mention of accessing land for extraction of aggregates for the purpose of facilitating road construction.

3.6.5 The institutional and operating context

Nauru Rehabilitation Corporation

NRC is a government-owned agency responsible for implementing, initiating, and coordinating the rehabilitation and development of lands impacted by phosphate mining.[198] NRC plays a crucial role not only in rehabilitating and managing land, but also in preparing EIAs and implementing EMPs for development project as required by international donors' safeguards.[199] Some of the issues addressed by NRC in the EIAs and EMPs are site clearance and preparation (rock breaking and blasting), health and safety (including workers and communities), land access and lease arrangements, waste management, removal of plant species and introduction of invasive weeds and pests, noise and air pollution and impacts on wildlife.

Republic of Nauru Phosphate Corporation

RONPHOS Corporation is a government owned agency responsible for maintaining and operation the phosphate industry in Nauru.[200] RONPHOS leases non-residential land from NRC for phosphate mining purposes.

[195] Nauru Rehabilitation Corporation Act 1997. http://ronlaw.gov.nr/nauru_lpms/files/acts/0cd2fde47fcc8d9eae606426f7a9db6e.pdf. Accessed 3/10/2023.

[196] Explosives Act 1924. http://ronlaw.gov.nr/nauru_lpms/files/acts/d470fdf606c8dfca5a2a251af7518fc6.pdf. Accessed 3/10/2023.

[197] Nauru Roads Act 2017. http://ronlaw.gov.nr/nauru_lpms/files/acts/a202037a6d8d16f1e878efa545e65bd4.pdf. Accessed 3/10/2023.

[198] Nauru Environmental Data Portal. https://nauru-data.sprep.org/group/4. Accessed 3/10/2023.

[199] Nauru Utilities Corporation for the Asian Development Bank. Solar Power Development Project: Initial Environmental Examination. https://www.adb.org/projects/documents/nau-49450-009-iee. Accessed 3/10/2023.

[200] RONPHOS. http://www.ronphos.com.au/About-Us-pg23613.html. Accessed 3/10/2023.

Department of Commerce, Industry and Environment

The Environment Division within the Department of Commerce, Industry and Environment is the main institutional agency that manages Nauru's environment and natural resources.[201] The division oversees the Environmental Impact Assessment process of development projects and ensures that the conditions attached to the EMP are implemented in order to mitigate adverse environmental impacts. Their responsibility also includes reporting to international project donors regarding project progress and safeguard implementation. They monitor and inspect project sites to evaluate compliance with the site-specific EMP and construction EMP and submit safeguard monitoring reports to donors, such as ADB.

3.7 Niue

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Niue	**Moderate** For the relatively small size of the country, there is a relatively substantial infrastructure plan valued at $173 million over 10 years (2023–2033).	- Limestone	**Low-medium** 2020–2022 imports: ~6.4 tons 2020–2022 exports: 0 tons Only 2 identified limestone quarries - small quantities of sand imports over the past 3 years indicate reasonable level of self-sufficiency. However, relatively large infrastructure pipeline may put pressure on existing quarries requiring increased imports of sand and other types of aggregate.

3.7.1 Geography and geology

Niue is a small, raised coral island in the South Pacific, some 2,400 km northeast of New Zealand, around 500 km south of Samoa, and 385 km east of the Vava'u Group of Tonga Figure 55. It covers an area of approximately 261 km^2 comprising a thin coastal strip of land 30–50 m wide and steep limestone cliffs rising up to a central plateau at around 60 m. The island is roughly circular in shape with a diameter of 18 km across. There are two large bays on the western coast and coral reef surrounding the island with a large break close to the capital and largest village, Alofi, on the western side of the island.

Niue is subject to tropical cyclones and heavy rainfall in the wet season, which lasts from December to March. However, due to the extremely porous nature of Niue's soil, ground water is limited and households must collect rainwater from rooftops.

[201] Nauru Utilities Corporation for the Asian Development Bank. Solar Power Development Project: Initial Environmental Examination. https://www.adb.org/projects/documents/nau-49450-009-iee. Accessed 3/10/2023.

Niue is a self-governing island country in free association with New Zealand. As of the last Census in 2022, its population was 1,681.[202] The island is commonly referred to as “The Rock” in connection with its traditional name “The Rock of Polynesia”.

Figure 55: Republic of Niue

Source: WorldAtlas.com

Niue rises steeply from an ocean depth of 4–5 km and is located near the edge of the Pacific plate, which is being subducted beneath the Australian plate at the Tonga Trench.[203] The raised Mutalau Lagoon is about 35 m from the sea level and the Mutalau Reef, the former atoll rim, is about 25 m higher. The uplift of Niue has been suggested to be due to upward bulge of the lithosphere before its subduction at the Tonga Trench. Dolomite is the only rock exposed on the island and goes up to 300 m depth. Some research suggests that volcanic rocks underlie the coral limestone capping at the depth of 300–400 m below sea level.

[202] Statistics Niue. https://niuestatistics.nu/. Accessed 09/09/2023

[203] Hill, P.J. (1983). Volcanic Core of Niue Island, Southwest Pacific Ocean. *BMR Journal of Australian Geology and Geophysics*, 8: 323–328.

3.7.2 Summary of aggregate extraction sites and known resources

Niue is composed almost entirely of highly porous limestone. There are two main limestone quarry sites (Tafalalo quarry), located near to Niue International Airport, as well as several burrow pits near the airport and along the Hakupu-Liku Road (Figure 56).[204] There are no obvious sources of marine sand or gravel given the limited number of sandy bays and deep ocean surrounding the island. Information about the reserves in these quarries and limestone production was not available at the time of the study.

Figure 56: Location of Limestone Quarry Sites Located near Niue International Airport

Source: Google Earth Pro imagery

3.7.3 Aggregates required for national infrastructure development

In March 2022, PRIF engaged the UK-based Integrated Transport Planning consultancy to develop Niue's NIIP, including identifying future infrastructure investment requirements.[205] The plan has been supported by PRIF and includes a long list of priority projects, including those ranked Essential, High priority, Medium priority, and Low priority. There are 18 Essential projects covering 12 sectors with an estimated cost of $173 million. Of note is that one of these Essential projects is in the quarry sector and involves replacing quarry machinery at a cost of $3 million.

[204] Toitu Te Whenua (Land Information New Zealand), Niue Quarry Polygons. https://data.linz.govt.nz/layer/52186-niue-quarry-polygons-topo-150k/

[205] Niue Infrastructure Investment Plan 2023–2033. https://theprif.org/document/niue/national-infrastructure-investment-plans/niue-infrastructure-investment-plan-2023-0#:~:text=This%20is%20the%20first%20Niue,economic%20and%20social%20development%20objectives. Accessed 09/09/2023.

PRIF has identified one key energy project, the Niue Renewal Energy Project Phase II. This project is budgeted at $13.2 million.[206] This project, if to proceed would likely require a modest amount of aggregate, depending on project specifics which are currently not available.

3.7.4 Overview of the legal and policy framework

Land and resource ownership

Land in Niue is comprised of Crown and Niuean Land. Crown land is land vested by the government, free from Niuean customs. Niuean land is held by Niueans according to customs and usages in Niue. The government is the only agency able to alienate (grant, sale, license, easement, mortgage, charge, encumbrance, trust, disposition) land for public purposes.

Land Act 1969

This provides for the control and tenure of land, the survey of land and registration of land titles.[207] Part 5 (s51) provides the procedure for taking of land for public purposes:

1. The Cabinet orders the Registrar to give notice of a proposal to take land for public purposes.
2. The Registrar prepares a plan for the area proposed to be taken including the names of the Leveki (trustee) Magafaoa (descent group that owns the rights to the land), or any lessee or occupier of that area.
3. The plan is then held in the Court and made available for public inspection.
4. The Registrar gives notice to the Leveki Mangafaoa and to any lessee or any other person possessing an interest on the land.
5. The notice advises that the plan can be inspected at the office of the Land Court and that the involving parties can write notification of their objection to the proposal and reasons for it.
6. The objection needs to be lodged within 30 days of the date the notice was received.
7. If there is no objection received by the Registrar, or if after the objection has been received, the Cabinet is of the opinion that effect should be given to the proposal to take the land for public purpose, the cabinet can recommend to the Minister that land must be taken under the Niue Amendment Act (No 2) 1968.[208]

Niue Amendment Act (No 2) 1968

This amendment of the Niue Act 1966 introduces chapters on land tenure, ownership of Niue land, compensation for acquired land, and procedures on Crown land grants and acquisition of land for

[206] PRIF Infrastructure Pipeline Projects. Internal report, 2023.

[207] Food and Agriculture Organization of the United Nations. Land Act 1969. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035505/. Accessed 19/09/2023.

[208] Niue Amendment Act (No. 2) 1968. https://www.legislation.govt.nz/act/public/1968/0132/1.0/whole.html#DLM389537. Accessed 19/09/2023.

public purposes. The act also sets out the responsibilities of the Land Court and Land Appellate court of Niue.[209]

The Environment Act 2015

This act governs matters concerning development projects that impact the environment. According to s8 of the act, Development Consent is required for any activity that has significant environmental impacts.[210]

Environment (Development Consent and Environmental Impact Assessment) Regulations 2017

These guidelines outline the development consent and EIA process including activities for which Development Consent is always required.[211]

The application for Development Consent is made to the Department of Environment with all the information included in Schedule 1. The Director advertises all applications of Development Consent and seeks for objections to the proposed developments. The Department then carries out the initial EIA. A decision is made based on the criteria listed in the document to issue the permit (with or without conditions) or not grant consent for the development.

Based on Schedule 2 of the Regulations, commercial extraction of aggregates, stone, shingle, sand, reef mud, or beach rock is an activity where Development Consent is always required.

The Minerals Act 1977

This act makes provisions for mining and mineral extraction activities.[212] According to Section 2 of the act, clay, sand, coral, gravel, stone, and earth are not considered as "minerals".

Continental Shelf Act 1964

This makes provision for the exploration and exploitation of continental shelf of Niue. Section 2 of the act defines "natural resources" to include living organisms and non-living resources of the seabed and subsoil.[213] However, there is no mention of aggregates. Section 8 of the act outlines the regulations for the exploration and exploitation of the continental shelf.

[209] Ibid.

[210] Food and Agriculture Organization of the United Nations. Environment Act 2015. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC181112/. Accessed 19/09/2023.

[211] Food and Agriculture Organization of the United Nations. Environment (Development Consent and Environmental Impact Assessment) Regulations 2017. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC181114/. Accessed 19/09/2023.

[212] Food and Agriculture Organization of the United Nations. Mining Act 1977. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC051782/. Accessed 19/09/2023.

[213] Food and Agriculture Organization of the United Nations. Continental Shelf Act 1964. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC074537/. Accessed 19/09/2023.

3.7.5 The Institutional and operating framework

The Department of Environment, Ministry of Natural Resources

The Department is responsible for administering the Environment Act and overseeing the Development Consent and EIA processes. It is therefore the body responsible regulating quarries.

Ministry of Infrastructure and Finance

This Ministry oversees a wide range of departments, as follows departments:

- Transport (Civil Aviation, Outside Services, Maritime, Heavy Plant, Fire and Rescue)
- Utilities Control (Building/Roads/Water/Electrical, Design and Engineering)
- Civil, Quarry and Roads Development
- Information, Communication and Technology
- Niue Power and Energy Authority
- Water Authority
- Ministry of Finance and Planning (Statistics, Immigration, Taxation Economics and Trade
- Project Management Coordination Unit, Aid Coordination)
- Customs and Revenue
- Asset Management
- PACER Plus
- Private Sector
- Niue Public Service Commission
- Whole of Government Reforms[214]

Of these, the Civil, Quarry and Roads Development Department is the key agency responsible for the regulation of the aggregates sector. It was established as a state-owned enterprise and is responsible for the operation of quarries and road maintenance.[215]

3.8 Palau

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Palau	**Low to moderate** Top 20 prioritized projects in the National Infrastructure Investment Plan (2021-2030) are valued at $243 million and will require substantial quantities of aggregate for construction. PRIF has identified projects valued at $59.7 million.	- Limestone - Volcanic rock - Lagoon / coastal sand and gravel dredging	**Low to medium** 2020–2022 imports: ~114.3 tons 2020–2022 exports: 0 tons Five active quarries with volcanic and limestone rock and sand should be able

214 Government of Niue. https://www.gov.nu/. Accessed 19/09/2023.

215 Niue National Transport Strategy and Short Term Action Plan 2017–2026. https://www.theprif.org/sites/default/files/2020-08/Niue%20Transport%20Strategy%20and%20Action%20Plan.pdf. Accessed 19/09/2023.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			to meet much of the aggregate demand, though past years have still required modest imports of sand, gravel etc.

3.8.1 Geography and geology

The Republic of Palau is an archipelago located in the Western Pacific consisting of around 340 islands and atolls covering an area of 458 km^2, around 1,500 km to the east of Manilla in the Philippines.[216] Of these islands, only eight are inhabited. Palau has a population of around 18,055 people (2020 World Bank estimate), the majority of who are on Koror, which is the former capital and the economic center of the nation (Figure 57). Koror itself has a population of around 11,119.[217] The capital, Ngerulmund, is on the largest island of Babeldaob which constitutes 75% of the total land area of Palau but the capital only has a population of around 318 people. Palau is an independent, democratic country in a "Compact of Free Association" with the US.[218]

[216] Government of Palau. https://www.palaugov.pw/who-we-are/#:~:text=We%20are%20a%20sovereign%20people,region%20of%20the%20Pacific%20Ocean. Accessed 19/09/2023.

[217] Office of Planning and Statistics Republic of Palau Koror, Palau (2022). Census of Population and Housing of the Republic of Palau. https://www.palaugov.pw/executive-branch/ministries/finance/budgetandplanning/census-of-population-and-housing/. Accessed 18/12/2023.

[218] Australian Department of Foreign Affairs and Trade. https://www.dfat.gov.au/geo/palau/republic-of-palau-country-brief#:~:text=The%20Republic%20of%20Palau%20consists,the%20east%20of%20the%20Philippines. Accessed 19/09/2023.

Figure 57: Map of Palau

Source: gisgeography.com

In terms of geology, the Palau's islands can be categorized into three major types: volcanic, limestone and low-lying reef islands and atolls.[219]

Volcanic islands

This group includes Babelthuap, Arakabesan, Malakal, western Koror and a number of smaller islets in the northern half of the Palau Reef. These islands are composed primarily of old arc-type volcanic rocks such as basalt, andesite and dacite fringed by coral limestone dating from 37.7 to 20.1 Ma.[220]

Babelthuap also comprises small deposits of interbedded sandstone, consolidated volcanic ash and shale on the east, west and south coast. Thick clay soil mantels the volcanic rock. There is also a narrow ridge of limestone on the south coast.

In western part of Koror, volcanic rock underlies smooth-sloped hills of moderate relief, while the eastern side is comprised of high limestone ridges.

[219] Gillespie, R.G. and Clague, D. eds. (2009). *Encyclopedia of Islands* (No. 2). Univ. of California Press. London, UK.

[220] United States Army Forces, Far East. (1956). *Military Geology of Palau Islands, Caroline Islands*. Intelligence Division Office of the Engineer, Headquarters. US Army Forces Far East.

Limestone islands

Peleliu and Anguar are uplifted, limestone covered platforms that have been extensively dissected by erosion and dissolution to form pitted and pinnacled karst topography. Much of the limestone has been partly phosphatized. Other limestone islands include Urukthapel and Eil Malk.

Reef and atoll islands

Reef islands include the three Ngemelis Islands north of Peleliu, and Ngargersiul, Ngerugelbtang, Ngarkim and Ngeregong on the reef northeast of Peleliu.

Kayangel and Ngaruangl Atolls are roughly circular in shape and composed of coral limestone and coral sand.

3.8.2 Summary of aggregate extraction sites and known resources

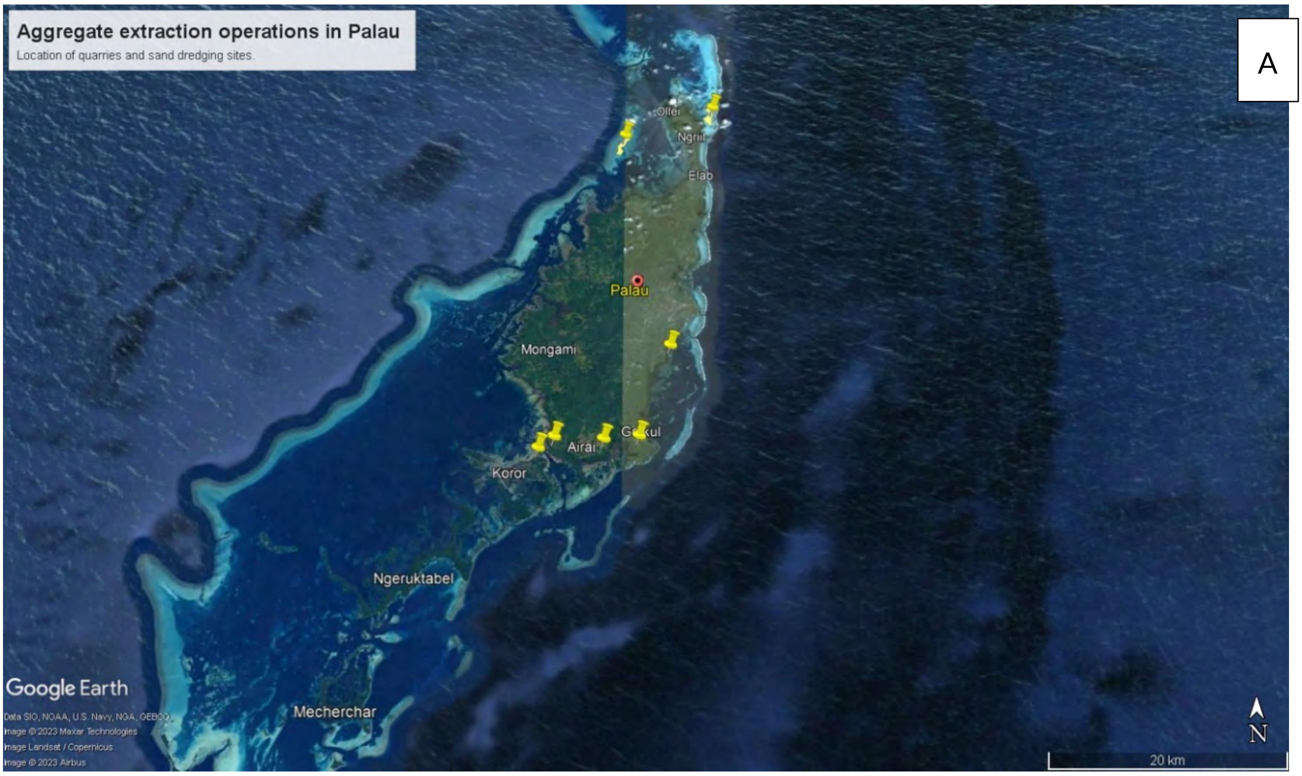
Little to no research is available on the aggregate resources available in Palau nor the quality of the material extracted. However, five possible active hard rock quarries and two dredging operations were identified by searching Palau business directories and consultant reports (Table 22). These were then verified using Google Earth Pro imagery (Figure 58).

Table 22: Summary of the Aggregate Extraction Sites in Palau[221]

Quarry	Aggregate Type	Location
Surangel Rock Quarry	Rock (type TBC_, gravel, black sand	Ked, Airai
Ngermellai Quarry	Limestone, boulders, overburden	Oikull, Airai
Mason's Rock Quarry	Limestone sand, gravel	Airai, Koror
Ngatpang Rock Quarry	Hard rock (tuff-breccia), gravel	Turangelbad, Ngerlul and Lou el Rorou in Ngatpang State
Palau National Quarry Inc.	Sand, gravel	Koror, Koror Island
Coral Dredging Basin	Sand, gravel	Ngchesar, Palau
RAM Corporation Dredging Operation	Sand	Ngarchelong State Government

Source: Compiled by the authors from sources listed in table footnote

[221] Surangel & Sons Co. https://surangel.com/oldconstruction/services-revised/mrp/rock-quarry/. Accessed 19/09/2023; KJP Consulting. (2018). *Draft Environmental Assessment, Proposed Ngarchelong Harbors Improvements and Sand Mining Project*. https://www.palaugov.pw/wp-content/uploads/2018/07/Ngerchelong-Sand-Mining-Project.pdf Accessed 19/09/2023; Ngatpang Quarry Corporation. (n.d.). *Environmental Assessment to Support the Earthmoving Permit Application for the Proposed Operation of the Ngatpang Rock Quarry, Ngatpang State, Palau*. https://www.palaugov.pw/wp-content/uploads/2018/08/Ngatpang-Rock-Quarry.pdf Accessed 19/09/2023.; Pacific Business Pages, Palau National Quarry. http://www.pacificbusinesspages.com/list/palau/palau-national-quarry-malakal. Accessed 19/09/2023.


Aggregate extraction operations in Palau
Location of quarries and sand dredging sites.
A
Ollei
Ngrii
Elab
Palau
Mongami
Airai
Koror
Ngeruktabel
Mecherchar
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2023 Maxar Technologies
Image Landsat / Copernicus
Image © 2023 Airbus
N
20 km


Quarry operations in Palau.
Location of quarry operations and the Coral Dredging Basin.
B
Coral Dredging Basin
Palau National Quarry Inc.
Ngermellai Quarry
Masons Quarry
Surangel Quarry
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2023 Maxar Technologies
Image © 2023 Airbus
N
10 km

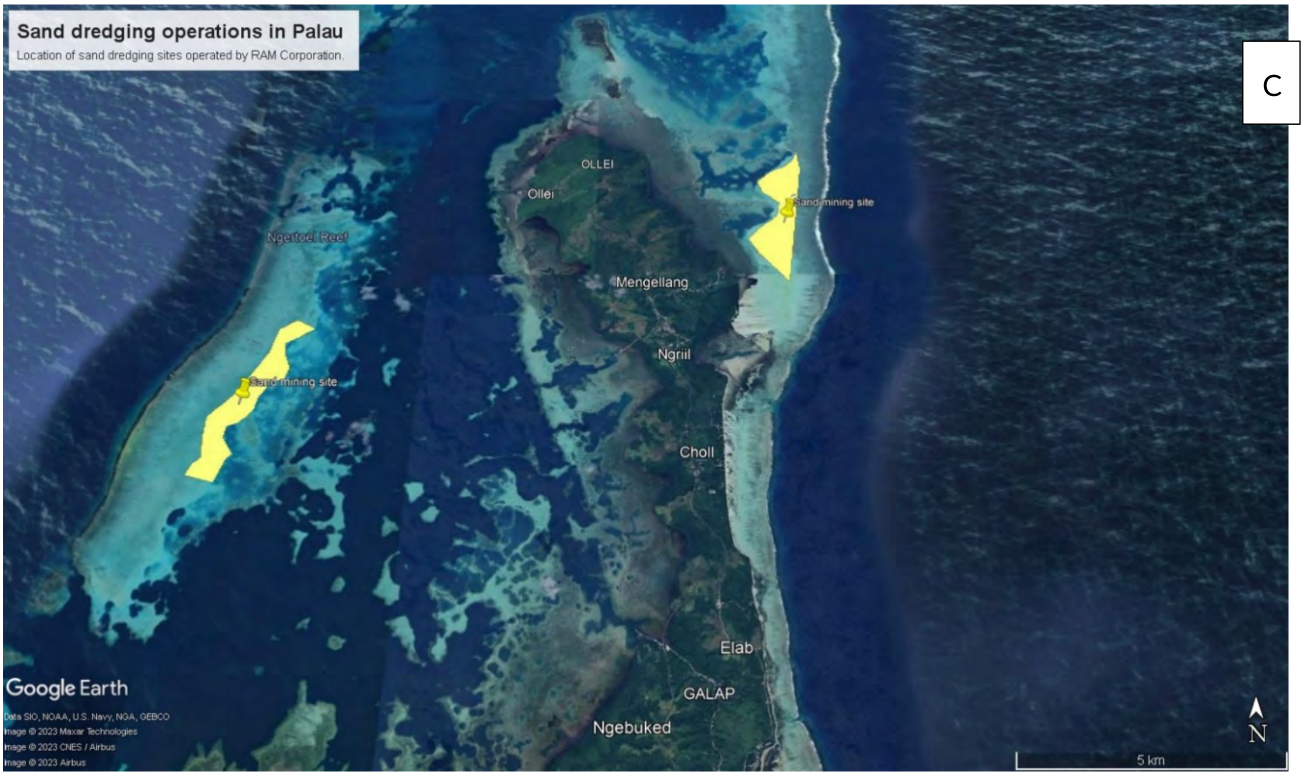


Figure 58: A) Location of aggregate extraction sites in Palau. B) Location of hard rock quarries and the Coral Dredging Basin in Palau. C) Location of sand dredging sites operated by RAM Corporation in Ngarchelong State

Source: Compiled by authors using Google Earth imagery and ArcGIS Pro

3.8.3 Aggregates required for national infrastructure development

With the help of the PRIF Coordination Office, Palau launched its 10-year NIIP 2021–2030 in 2021 covering 14 sectors. This plan was a result of a consultative process involving a wide range of stakeholders from both government and non-government entities, including the business community.[222] The plan came at a critical time, just after the COVID-19 pandemic with the aim to sustain a relevant, efficient, and effective program of investing in new infrastructure projects to meet the country's development agenda. The NIIP also reviewed the investment needs for the existing infrastructure and how they aligned with the new ones.

The plan identified a list of the "top 20 priority projects", which cover infrastructure for resource development, utility renewal and expansion, and strengthening central government administration. There are several very large infrastructure projects which will require substantial quantities of aggregate for construction. Notable projects include a New Commercial Sea Port ($120 million), Resilient Urban Development - Municipal services for housing subdivision ($35 million), and $22.25 million for two airstrips in Peleliu and Angaur. The total infrastructure investment on the top 20 projects alone is more than $243 million.

[222] Palau National Infrastructure Investment Plan (NIIP) 2021–2030. https://www.theprif.org/document/palau/national-infrastructure-investment-plans/palau-national-infrastructure-investment#:~:text=The%20Palau%20National%20Infrastructure%20Investment,develop%20our%20economy%20and%20society. Accessed on 19/09/2023.

Projects identified by PRIF for potential investment are show in Table 23.

Table 23: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for Palau and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Replacement of Minatobashi Bridge	20.0	Very High	Requires large volume of aggregates for concrete, and other adjoining structures. Significant amount of boulder will be required for backfill and riprap.
Energy	Sustainable Blue Prosperity Program (with renewable energy and energy resilience component)	TBD	Moderate to high	Requires moderate to high amounts of aggregates. However, the final design and scope will determine the exact amount of aggregate required.
Water and Sanitation	Koror-Airai Sanitation Project (additional funding)	4.0	Low	Based on the budget (additional funding), the amount required might be low. However, the original project must have used a significant amount of aggregates.
Water and Sanitation/Urban Development	Koror-Airai Sanitation Project- Phase 2	25.7	High	Requires large volumes of aggregates for concrete, and sand for water treatment. Likely to involve the construction of reservoirs, pumping stations, water treatment plants, urban sewage treatment plants and pipelines among others.
Water and Sanitation/Urban Development	Dabeldaob Island Urban Resilience Project	10.0	High	As above
Total ($)		**59.7 million**		

TBD = to be determined.

Source: PRIF 2023; relevant project reports where available

3.8.4 Overview of the legal and policy framework

Land and resource ownership

Land can only be owned by Palauan citizens though foreigners are allowed to lease land with terms up to 99 years. Land can be owned by individuals, families, chiefs of the village or by clans and can be sold or bought by Palauans.[223] Public lands are lands which were owned or maintained by the

[223] SPREP. (2018). *Palau: Review of Environmental Legislation.*

https://www.sprep.org/attachments/Publications/EMG/sprep-legislative-review-palau.pdf Accessed 19/09/2023.

Japanese administration or, after World War II, the Trust Territory Government as government lands or lands acquired for public purposes.[224]

The Trust Territory Land Planning Act (Title 31 Palau National Code)

This act outlines the guidelines for land use planning across all districts in Palau. It establishes a Planning Commission within the government of each district. The act requires the inclusion of environmental considerations within the Master Plan produced by the Planning Commissions in each district, comprising a conservation section with any plans for the conservation, development, utilization and protection of natural resources, including forests, soils, rivers and other waters, harbors, fisheries, wildlife, minerals, and other natural resources.[225]

The main responsibility of the Planning Commission is administering the zoning of land. For example, in Koror state, Koro Zoning Laws (listed in Title 31 of the Palau National Code) classify land in the following categories: (A) agriculture; (R-1) Single Family Residential; R – 2 Single Family Residential; (R-3) Multiple Family Residential; (C) Commercial; (RV) Resort Center; (I-1) Industrial 1; (I-2) Industrial 2; (CD) Conservation; (HP) Historic Preservation and (PD) Planned Development.

Palau National Code

The Palau National Code consists of a combination of laws passed by National Congress and represents the previous colonial laws implemented by foreign administrations and several additional laws that have been enacted more recently.

The Constitution of Palau outlines its administrative structure designating 16 traditional municipalities of Palau as states. All states have the authority to formulate their own legislature and elect their own head of state. However, the Constitution and the Palau National Code supersede other state government legislations.

Title 24 of the Palau National Code (Division 1, 2 & 3)

Division 1- Environmental Quality (encompasses the Environmental Quality Protection Act) and provides for the establishment of Palau Environmental Quality Protection Board.

Division 2 -provides regulations concerning the protection of wildlife, endangered species, protection of land life which is restricted to birds with exception of 4 species, and illegal fishing and use of explosives, poisons, and chemicals.

Division 3- provides for the protection of two legally protected areas in Palau, the Ngerukewid Islands Wildlife Reserve, and the Ngerumekaol Spawning Area.

Policies

Sustainable Land Management Policy 2012

The policy forms the basis for a strategic action plan to ensure sustainable management of natural and cultural resources and a foundation for integrated land use and management.[226] The policy

[224] ADB. (2017). *Private Sector Assessment for Palau, Policies for Sustainable Growth Revisited*. https://www.adb.org/sites/default/files/institutional-document/230131/palau-psa-2017.pdf. Accessed 19/09/2023.

[225] SPREP. (2018). *Palau: Review of Environmental Legislation*. https://www.theprif.org/sites/default/files/documents/sprep-legislative-review-palau.pdf. Accessed 19/09/2023.

[226] Food and Agriculture Organization of the United Nations. Sustainable Land Management Policy. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC222080/. Accessed 19/12/2023.

includes 10 comprehensive elements such as increasing capacity for land use planning and sustainable land management, developing and implement climate change adaptation strategies and others. This policy aims to increase capacity for land use planning and sustainable resource management by creating nationwide land use maps to assist in decision-making processes, carry out studies to determine carrying capacity of natural resources, and participate in international programs related to sustainable management of these resources.

The document mentions "minerals" in the context of strengthening Best Management Practices and regulation to address mineral exploration. Other words, such as "aggregates", "gravel" and "sand" are not mentioned.

Environmental Quality Protection Act (Chapter 1 of Title 24 of Palau National Code)

The act is divided into four sections: I) General Provisions; II) Palau Environmental Quality Protection Board; III) Environmental studies and decisions and IV) Implementation, enforcement, and court action.[227] According to the act, the Palau Environmental Protection Board is appointed by the President and consists of seven members. The board's responsibility is to enforce regulations including monitoring, inspection, and record-keeping procedures; establish criteria for land and water present and future uses and publish guidelines and technical manuals establishing procedures and criteria for enforcement of the Board's regulations. Section 3 states that government decisions should be made based on natural and social science and, traditional wisdom in order to avoid impacts on the environment.

Environmental Impact Statement Regulations (Chapter 2401-6)

The EIA Regulation defines when an EIA is needed and provides the details of the EIA process.[228] According to the regulations an EIA is required for any of the projects that propose:

1. To use national or state land
2. To use national or state funds
3. Any use within any land which has been or may be classified as conservation district
4. Any use impacting coastal waters or wetlands
5. Any use within sites of historical significance as designated by the Palau Historic Preservation Office
6. Any proposed action which the board determines may have significant impact on the environment

Contents of the EIA must include:

1. Identification of applicant
2. identification of agencies and organizations consulted in the assessment
3. General description of the project's technical, economic, social, and environmental characteristics
4. Summary description of the impacted environment, including suitable and adequate location and site maps
5. Identification and summary of major impacts and alternatives considered
6. Proposed mitigation measures

[227] Food and Agriculture Organization of the United Nations. Environmental Quality Protection Act (Chapter 1 of Title 24 of Palau National Code). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC006997/. Accessed 19/12/2023.
[228] Food and Agriculture Organization of the United Nations. Environmental Impact Statement Regulations (Chapter 2401-61). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC032800/. Accessed 19/09/2023.

The EIA is submitted to the Environmental Quality Protection Board, which decides to grant or reject the submission based on the criteria outlined in the Environmental Impact Statement Regulations (Chapter 2401-61).

Earthmoving Regulations (Chapter 2401-1)

The Earthmoving regulations deal with earthmoving operations, described as any activity or construction work that disturbs or alters the earth including quarrying, dredging, uncovering, displacing, or relocating of soil, rock, and coral.[229] All activities must operate in accordance with the regulation so as to prevent erosion, and sedimentation, and must incorporate control measures to prevent these impacts.

3.8.5 The institutional and operating context

Ministry of Agriculture, Fisheries, and the Environment

The Bureau of Environment within the Ministry of Agriculture, Fisheries, and the Environment is the agency responsible for protecting Palau's natural environment, conservation of resources and promotion of sustainable development through regulatory enforcement.[230] The Division of Forest, Land, and Water Management within the Bureau of Environment aims to manage and protect Palau's natural resources through rehabilitation, reforestation actions, Best Practices and integrated management approaches.

Ministry of Public Infrastructure and Industries

This Ministry has seven bureaus, two of which most relevant to the governance of the aggregates sector in Palau. They include the Bureau of Land and Survey, which has two divisions - the Division of Surveying and Mapping and Division of Land Resources Information.[231] Their main responsibility is to provide their services to the Land Court, Palau Public Lands Authority, State Public Lands Authorities, the private sector, and the general public.

The Bureau of Public Works is comprised of four divisions: the Division of Facilities and Maintenance, Division of Road and Equipment/Capital Maintenance and Utilities, Division of Capital Improvement Project, and Solid Waste Management.[232] The main responsibility of the Bureau of Public Works is to monitor and report on the implementation the NIIP.[233]

[229] Food and Agriculture Organization of the United Nations. Earthmoving Regulations (Chapter 2401-1). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC032778/. Accessed on 19/09/2023.

[230] Republic of Palau National Government. https://www.palaugov.pw/executive-branch/ministries/agriculture-fisheries-and-environment/environment/. Accessed 19/12/2023.

[231] Republic of Palau National Government. https://www.palaugov.pw/executive-branch/ministries/public-infrastructure/bureau-of-land-and-survey/. Accessed 19/12/2023.

[232] Republic of Palau National Government. https://www.palaugov.pw/executive-branch/ministries/public-infrastructure/bureau-of-public-works/. Accessed 19/12/2023.

[233] Palau National Infrastructure Investment Plan 2021–30. https://www.theprif.org/sites/default/files/documents/PRIF_PalauNIIP-2021_Web_0.pdf. Accessed 19/9/2023.

Environmental Quality Protection Board

This is a government agency comprised of seven members appointed by the President with consent of the Senate.[234] The responsibilities of the board include:

1. Produce an Environmental Quality Report every year to transmit to the President and the Senate
2. Manage water resources according to the United States Safe Drinking Water Act
3. Administration and development of a permit system for the discharge of pollutants
4. Monitor proposed actions and/or projects and oversee their EIA process.

The Board is responsible for administering the Earthmoving Regulations and therefore has regulatory responsibility for quarrying, dredging and other earthmoving activities.[235]

3.9 Papua New Guinea

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
PNG	**Very high** Very large infrastructure pipeline in the order of $1,826.4 million for potential PRIF projects alone. In addition, the "Connect PNG Plan 2020-2040" will require massive quantities of aggregate to build or rehabilitate 4,200km of national roads and 16,200km of provincial and district roads.	- Volcanic rock - Limestone - River gravel and sand	**TBC** 2020–2022 imports: ~ 1,450.4 tons 2020–2022 exports: 143 tons Over 23 quarries identified at time of writing plus potentially numerous other resources (and quarries) not identified. However, PNG's infrastructure pipeline, including road building is massive and will require extremely large quantities of aggregates for roads and other infrastructure. Also noteworthy is that PNG still imports aggregate (~1,450 tons between 2020–2022). Aggregate resources are potentially available but surveying and establishing a significant aggregates sector will require substantial resources and capacity building.

[234] Food and Agriculture Organization of the United Nations. Environmental Quality Protection Act (Chapter 1 of Title 24 of Palau National Code). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC006997/. Accessed 19/09/2023.

[235] Secretariat of the Pacific Regional Environment Programme (SPREP) and EDO NSW. (2018). *Review of Natural Resource and Environment Related Legislation, Palau*. https://www.sprep.org/attachments/Publications/EMG/sprep-legislative-review-palau.pdf Accessed 27/03/2024.

3.9.1 Geography and geology

Papua New Guinea (PNG) is located in the southwest Pacific Ocean just below the equator between latitude 0° and 6° South and longitude 147° East, around 160 km north of Australia.[236] It is the world's second-largest island with a total area of 462,840 km^2 and a coastline of 5,152 km. PNG comprises the eastern half of the island of New Guinea, and some 600 offshore islands between the Coral Sea and the South Pacific. Port Moresby, located in the National Capital District (NCD) on the southern coast is the capital and the largest city of PNG (see map in Figure 59). Administratively, PNG is divided into 22 provinces, including the autonomous region of Bougainville and the NCD.

The geology of PNG can be grouped according to three major categories, namely: 1) the Australian Craton that underlies western PNG and the Torres Strait, 2) the mountainous New Guinea Orogen with sedimentary, volcanic and igneous rocks in central PNG, and 3) the Melanesian Arc, comprised of a series of island arcs and mountain ranges in the east [237].

PNG's mainland is composed of multiple terranes that were accreted to the northern Australian continental margin during the Cenozoic. Its geological history involves volcanic arc initiation, closure, and accretion over the last 30 million years. These processes have resulted in several belts of porphyry deposits in continental and oceanic settings. There have been various subducting tectonic plates and volcanic arcs over time which have led to the right conditions that resulted in multiple porphyry rock deposits. There are numerous Plio-Pleistocene granites on t he ground surface like the ones at OK Tedi, the location of PNG's biggest copper and gold mine. Australia and PNG share the same geomorphic histories as they are geographically adjacent, sharing some tectonic units.

The country is dominated by narrow trending mountain ranges which are composed of Cretaceous and lower tertiary volcanic, intrusive, and deformed sedimentary, metamorphic, and crystalline rocks. The country has some of the most active volcanoes globally.[238]

[236] Löffler, E. (1980). Geology and Geomorphology of the New Guinea High Mountains. *The Alpine Flora of New Guinea*, 1: 29–57.

[237] Ollier, C. D. (1979). Evolutionary Geomorphology of Australia and Papua: New Guinea. *Transactions of the Institute of British Geographers*, 4(4): 516-539.

[238] Stead, D. (1990). Engineering Geology in Papua New Guinea: A Review. *Engineering Geology*, 29(1): 1–29.

Figure 59: Map of Papua New Guinea

Source: geology.com

PNG is well-endowed in natural resources with extensive mineral deposits and natural oil and gas reserves. However, due to the lack of publicly available data, extensive rainforest cover, rugged terrain, and lack of infrastructure, PNG's geology and tectonic evolution are still not fully understood.[239]

3.9.2 Summary of aggregate extraction sites and known resources

Sources of aggregate in PNG range from hard rock quarries to river and beach sand and gravel, with all major types of aggregate available depending on location (e.g., river gravel and sand, volcanic rock, beach sand, limestone, etc.). Some researchers have suggested that in previous years, river extraction was the major source of aggregates, especially for local domestic use.[240] However, most large projects such as road infrastructure construction projects source aggregates from blasting and crushing volcanic rocks from hard rock quarries.

Due to the vast area of land in PNG, the country's diverse geography, and multiple agencies involved in data collation, there is limited knowledge of the quarry, river gravel, and sand resources in the country. Historically, there would have been scores of quarries providing materials for PNG's major road projects over the decades but records for these are not publicly available. One possible reason for this is that many of these quarries would have been project-specific and therefore hard to trace after the project was completed. Some, of course, would have been borrow pits used to supply materials for specific sections of road throughout the country and for which records may not even exist. But a more fundamental problem is the lack centralized database of all quarries and river

[239] Sheppard, S., & Cranfield, L. (2012). *Geological Framework and Mineralization of Papua New Guinea—An Update*. Port Moresby: Mineral Resources Authority; Mudd, G. M., Roche, C., Northey, S. A., Jowitt, S. M., & Gamato, G. (2020). Mining in Papua New Guinea: A Complex Story of Trends, Impacts and Governance. *Science of the Total Environment*, 741: 140375.

[240] Bird, E. (2010). Papua New Guinea. In Bird, E.C.F. (ed.) *Encyclopedia of the World's Coastal Landforms*. Dordrecht: Springer.

gravel/sand operations in PNG, something confirmed by a senior staff member of the Mineral Resources Authority (MRA) during the course of this study.[241] Apparently, the MRA only has records of a “handful” of quarries (which the consultants have requested but are yet to receive), while data on the many others is kept by other agencies, particularly PNG’s Department of Works and Highways.

It has been possible to obtain a partial picture of the commercial quarries sector located near major cities in PNG, as summarized in Table 24. Commercial quarries are those whose existence does not depend exclusively on a specific project. Some of these quarries operate for years depending on the availability of the resources and lease permits required for its operations. Using the PNG Business Directory, it was possible to identify the names of some of the main commercial companies operating in the aggregates sector, determine the GPS coordinates of their quarries using Google Earth, and then map them.

Figure 60 shows the location of quarries around Port Moresby, Figure 61 shows the location of quarries near to Lae, while Figure 62 shows the location of the only known commercial quarry in Gulf Province on the south coast of PNG. There may be many more though information is not currently available. The quarries identified appear to be a mix of hard rock, limestone, and sand and gravel. Monier’s Nebiri quarry is notable for its production capacity, which reportedly has proven capacity to produce 1 million tons of limestone and igneous rock per year.[242]

There is also some limited information on river sand and gravel operations. A study by SOPAC in 2009 identified deposits of good quality river gravel and sand near Vanimo town on PNG’s north coast.[243] A deposit at the Waramei River was assessed as having a total resource of 2.2 million m^3 with an extractable resource of about 0.6 million m^3. The aggregate was predominantly composed of plutonic rock fragments with minor amounts of volcanic rocks and limestone. The deposit was assessed at the time as being ten times bigger than a nearby deposit on the Wara Bili River, with superior aggregate suitable for various road building and construction applications. It is not known if the Waramei deposit is being extracted.

In addition, Brisbane-based Mayur-Resources has a lease on a limestone quarry located next to its proposed quicklime and cement factory, around 25 km northwest of Port Moresby near Lea Lea. The quarry is reported to have the capacity to produce 500 kt of raw limestone per annum for the cement factory.[244]

[241] Personal communication with MRA staff. Dated 26/09/2023.

[242] Monier Limited. https://monier.com.pg/products/quarry/.

[243] Tawake, A. and Mosusu, N. (2009). Assessment of Selected River Aggregate Deposits at Waramei and Wara Bili Rivers, South Vanimo. *Papua New Guinea Technical Report EU EDF* 8 – *SOPAC Project Report* 138.

[244] Mayur Resources, AXS announcement 26 July 2022. Updated DFS for Central Cement and Lime Project https://bit.ly/3PSQBaL.

Table 24: Commercial Quarries in Papua New Guinea

Company	Aggregate Resource Location	Aggregates Type
Central Sands Supplies Limited	Port Moresby, National Capital District, but with multiple river extraction sites	River Sand
PNG Concrete Aggregates	Lae (exact quarry location unknown)	Sand and gravel
PICSA ONG Group	-9.459852 147.1825216	Sand and gravel
Sunshine Quarry	Port Moresby, National Capital District	Unknown, but likely limestone
Monier Quarry / Nebiri Quarry	Port Moresby, National Capital District (Nebiri)	Limestone and igneous rock (dolerite)
R & Sons Construction Limited	Lae	Sand and gravel
Rouna Quarries	Port Moresby, National Capital District	Hard Rock Quarry
Dekenai Constructions	Unknown	Hard Rock Quarry
JV PNG Investment Construction Ltd	Lae	Sand and gravel
POM Stones	Port Moresby, National Capital District	Unknown
Stratostructure Ltd	Port Moresby, National Capital District	Unknown
Boinamo Enterprises Ltd	Lae	Unknown
Huon Machinery	Lae	Unknown
Cameron Construction Services Ltd	Lae	Sand and gravel
Enga Quarries Ltd	Mount Hagen (exact quarry location unknown)	Sand and gravel
Quarries and Aggregate Suppliers Ltd	Port Moresby, National Capital District (exact quarry location unknown)	Fine and coarse sand, gravel and Diorite
Blue Stone Quarry	Madang (exact quarry location unknown)	Hard Rock Quarry
9 Mile Quarry	Port Moresby, National Capital District	Limestone and dolerite (to be confirmed)
Behori Quarry	Port Moresby, National Capital District	Unknown
Epo Quarry	Unknown	Uknown
Elu Quarry	Highlands Rd - exact location unknown (now closed)	Igneous rock (TBC)
Kabulbul Quarry	Highlands Rd - exact location unknown	Igneous rock (TBC)
Tomiare Quarry	Highlands Rd - exact location unknown (project-specific)	Igneous rock (TBC)
Kumarini Quarry	Highlands Rd - exact location unknown (Project-specific)	Igneous rock (TBC)

Source: PNG Business Directory https://www.pngbusinessdirectory.com/category/sand-gravel-and-soil-supplies/Lae; Nation Wide PNG Pages https://www.nationwidepngpages.com/directory/780/quarry; Bluestone Quarry https://vymaps.com/PG/Blue-Stone-Quarry-104249318012753/.

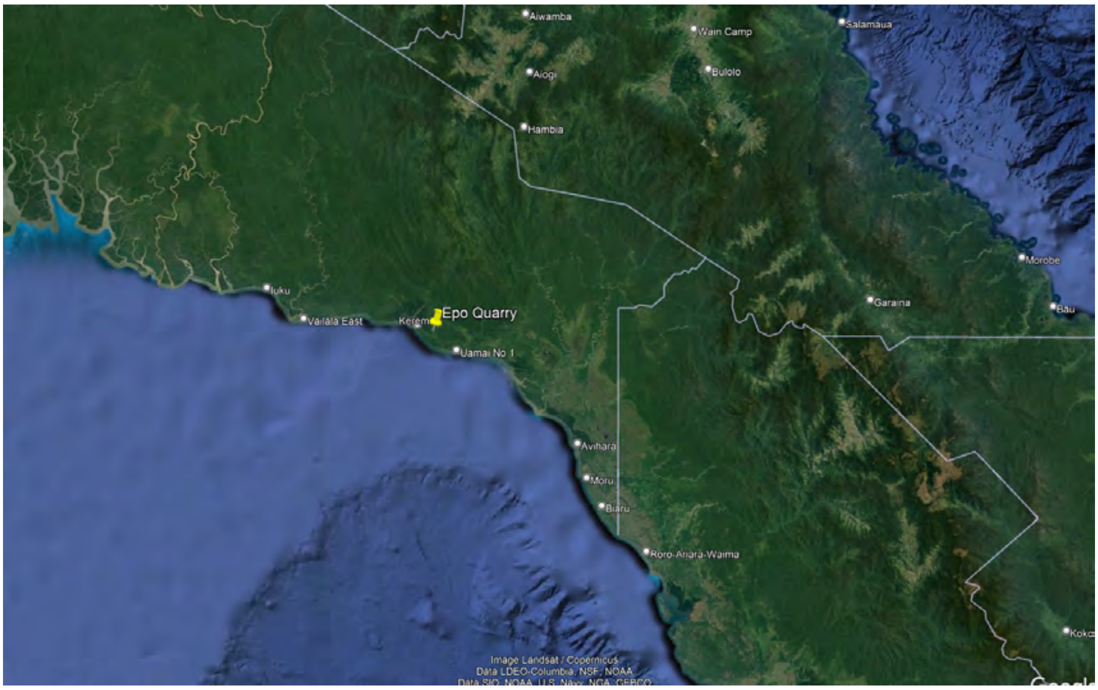
Figure 60: Location of Aggregate Quarries in the Port Moresby Area

Source: Google Earth imagery

Figure 61: Location of Commercial Quarries in the Lae Area

Source: Google Earth imagery

Figure 62: Location of Known Commercial Quarry in Gulf Province



Source: Google Earth imagery)

3.9.3 Aggregates required in the national infrastructure development plan

In 2010, PNG launched its 20-year National Development Strategic Plan (DSP 2010–2030). One of the strategic pillars of development is the investment and development of economic and social infrastructure. Several projects have been undertaken and some are still in the pipeline. Some of the key infrastructure projects are those in the transport sector comprising roads, marine facilities, and airports. Other economic infrastructure under consideration includes utilities such as water and sewage systems, telecommunication, electricity grids, and industrial estates, among others. Social infrastructure investment ranges from the construction of health facilities and residential housing estates.

In 2020, the government of PNG also launched the “Connect PNG Plan 2020-2040”, which will see a total of 4,200 km of national roads and 16,200 km of provincial and district roads built, rehabilitated, and maintained by 2040. This ambitious plan will require a massive quantity of materials, especially aggregates for road base, sealing chips and concrete.

Several projects have been identified for support by PRIF members, including in the energy, health, and urban development (water and sanitation) sectors. All these projects will require a significant amount of aggregates to construct different facilities/structures. Table 25 provides a summary of these projects and an indicative picture of demand of aggregates for projects in the pipeline.

Table 25: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for Papua New Guinea and Predicted Aggregate Demand

Sector	Planned Development/Project Name	Budget ($M)	Aggregate Demand	Assumptions
Transport	Preparing Port Moresby Urban Mobility Plan	Technical assistance only ($1.5 M)	None	Planning only – no construction

Sector	Planned Development/Project Name	Budget ($M)	Aggregate Demand	Assumptions
Transport	Sustainable Highlands Region Core Road Network Phase 1	165	Very high	Requires very high volumes of aggregates for concrete, asphalt, and pavement layers (dependent on design and specifications).
Transport	Sustainable Highlands Highway Investment Program – Tranche 3	178.0	Very high	Requires very high volumes of aggregates for concrete, asphalt, and road pavement layers (dependent on design and specifications).
Transport	Civil Aviation Development Investment Project III	300.0	Very high	Requires very high volumes of aggregates for concrete, asphalt, and pavement layers for roads, hangers, runways, taxiways, aprons etc. (dependent on design and specifications).
Transport	PNG Ports Daru	20.5	Moderate to high	Requires moderate to high volume of aggregates for concrete and boulders for breakwaters, and other facilities
Transport	PNG Trans-National Highway	205.0	Very high	Requires very high volumes of aggregates for concrete, asphalt, and road pavement layers (dependent on design and specifications).
Transport	Connect PNG Program-Bridge Upgrade on the Ramu and Sepik Highways	No data	Very high	Likely to require very high volumes of aggregates for concrete and boulders for base stability and slope protection
Transport	Tokua Airport	No data	Very high	Requires very high volumes of aggregates for concrete, asphalt, and road pavement layers, hangers, runways, taxiways, aprons etc. (dependent on design and specifications).
Transport	Resilient Transport Project 2	120	Very high	Requires very high volumes of aggregates for concrete, asphalt, and road pavement layers (dependent on design and specifications).
Energy	Power Sector Development	>250.0	Very High	Requires very high volumes of aggregates for concrete, asphalt, and boulders for slope protection.
Energy	Transmission and Distribution	No data	Moderate	Requires moderate volume of aggregates for concrete (especially for pylon foundations and power stations)
Energy	Clean Energy Development Project	250.0	high	Requires high volume of aggregates concrete for specific structures such as wind turbine foundations and construction of power stations.

Sector	Planned Development/Project Name	Budget ($M)	Aggregate Demand	Assumptions
Energy	PNG Ramu 1 Hydropower	104.6	Very high	Requires very high volumes of aggregates for concrete, asphalt, and boulders for slope protection.
Energy	PNG Electrification Partnership	57	Pending further details of the project	TBC
Energy	National Energy Access Project	100	Pending further details of the project	TBC
Water and Sanitation	Urban Water Supply and Sanitation Project	30.9	Moderate to high	Requires moderate to high volumes of aggregates for concrete and sand for water treatment/purification
Urban Development/Water and Sanitation	Urban Water Supply and Sanitation Project	35.4	Moderate to high	Requires moderate to high volumes of aggregates for concrete and sand for water treatment/purification
Health	Construction of Perinatal Medical Centre at Port Moresby Hospital	No data but 25.0 allocated for technical assistance so far	Moderate	Requires moderate volume of aggregates for concrete to construct the center
Total		**1,816.4** (not including TA)		

PNG = Papua New Guinea, TA = technical assistance, TBC = to be calculated.

Source: PRIF, 2023

Based on the modest aggregate imports into PNG over the past 3 years, i.e., only 1,450 tons,[245] there must be significant production capacity in the sector to meet current demand. However, not enough is currently known about the sector to determine the country's capacity to meet what will be massive aggregate demands to meet its infrastructure pipeline in the coming years.

3.9.4 Overview of the legal and policy Framework

Land and resource ownership

Part II of the Papua New Guinea Land Act 1996 states that all land other than customary land is the property of the State. PNG generally has generally two land tenure systems, i.e., customary and alienated land ownership.

Customary land

Most land in PNG is held under customary land ownership. Customary land ownership generally recognizes the traditional users of land and their personal and clan arrangements for land use. The Land Act 1996 defines customary land as land "that is owned or possessed by an automatic citizen by virtue of rights of a proprietary or possessory kind that belongs to that citizen or community and arise from and are regulated by customs." Under customary land, every member of a landholding entity, such as a tribe, clan, or family, is vested with the right to use and access the land. Despite the landowners owning the land, they cannot sell or lease land to foreign investors, instead, it is the government that must acquire the land from its traditional owners and then lease it to the foreign investor. However, before a mine / extractive operation can be established, it is necessary for

[245] UN Comtrade database https://comtradeplus.un.org/. Accessed 20/09/2023

companies, government, and landowners to participate in a Development Forum, the purpose of which is bring together key stakeholders to negotiate and agree on all aspects of the project and establish how the benefits are to be shared.[246]

Alienated land

This tenure refers to the rest of the land that has been acquired from the customary/traditional landowners by the government for its own use or private investment. Some alienated land is held as freeholds other than by the government. Most of the foreign investments are on alienated land. Alienated land can be freehold or leasehold. Therefore, when a prospective investor wants to set up a quarry, he/she must go through the Land Board in the Ministry of Lands & Physical Planning. However, as already stated above, in the case of customary land, a foreign investor cannot lease land directly from the customary landowners; the process must be done through the government.

Under section 82 of the act, all minerals and material substances in or on the land are managed by the state for the citizens. Therefore, irrespective of land ownership, all natural minerals and substances are the property of the government.

Environment Act 2000

This act is the main legislation overseeing matters regarding the management of the environment. It covers all of the following areas:

1. To provide for the protection of the environment in accordance with the Fourth National Goal and Directive Principle of the Constitution
2. To provide for the protection and management of the natural environment from the impacts of development activities
3. To provide for the protection of the environment from environmental harm
4. To provide for the protection and management of national water resources[247]

Environment Act 2000 (last amended 2014)

This act amends the previous Environment Act 2000.[248] Key changes include updates to, or further elaboration of, sections related to: environmental audit and investigation, offsets, environmental harm, permits and conditions, and environmental offences and penalties. There are also changes to the situations under which the Director of Environment issues notification to project developers to undertake EIAs, as well as the matters to be included. Developers are now required to submit a report prior to undertaking an EIA, as well as the submission of an EIS that is subject to public review. The amendment also redefines the functions and powers of both the Minister and Director of Environment (Sec. 54).

Also of importance, are changes to Section 12 that define the environmental implications of developments in terms of three levels (1, 2 and 3). Level 3 activities are those "that may result in serious environmental harm or might have a significant negative impact on a matter of national importance". Level 2 activities include those "that may result in material environmental harm or

[246] ICMM. (2017). *Indigenous Peoples and Mining Good Practice Guide, Second Edition*. https://www.csrm.uq.edu.au/publications/good-practice-guide-indigenous-peoples-and-mining. Accessed 20/12/2023.

[247] Food and Agriculture Organization of the United Nations. Environment Act. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC070607. Accessed 31/12/2-23.

[248] Food and Agriculture Organization of the United Nations. Environment (Amendment) Act 2014 (No. 10 of 2014). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC147641. Accessed 20/09/2023.

might have negative impacts on a matter of national importance". All other activities are considered Level 1.

Environment (Permits) Regulation 2002

These regulations outline the procedures of application for an Environment Permit.[249] As provided for in Sec. 41 of the Environment Act 2000, these permits are issued for all activities that involve:

1. construction of works, land clearance, demolition, excavation, or other works in land or water
2. installation, operation or maintenance of plant or equipment
3. activities for the purpose of extracting or harvesting natural resources
4. release of contaminants to air, land, or water

Separate environmental permits are issued by CEPA or Department of Mines for gravel extraction for construction materials. To obtain the permit, an EIA may be required.

Environment (Prescribed Activities) Regulations 2002 (EPAR)

The Environment Act 2000 and the Amended Act of 2014 are accompanied by a regulatory framework called the Environment (Prescribed Activities) Regulation 2002 which are of direct relevance to the aggregates sector.[250] The Regulations list all activities categorized as Level 2 and 3.

Category number 2.3: Gravel extraction operating continuously for more than 6 months and involving the extraction of no greater than 10,000 tons per annum is Level 2 (Category A) activity.

Category number 7.5: Gravel extraction of more than 10,000 tons per year is Level 2 (Category B) activity.

Category number 2.4: Quarrying involving extraction of no greater than 100,000 tons per year is Level 2 (Category B) and more than 100,000 tons per year is Level 2 (Category A) (Number 7.4)

Category number 17.3: Extraction of offshore coral deposits for roading, commercial lime-making or similar use is a Level 3 activity.

Conservation and Environment Protection Authority (CEPA) Act 2014

The CEPA Act establishes PNG's Conservation and Environment Protection Authority and outlines its powers, functions, and conservation principles, as well as the functions and role of the Minister. CEPA is empowered to do all things necessary to conserve and protect PNG's environment, as prescribed under PNG's environmental laws and regulations and to follow the policy directions of the Minister. It also coordinates with provincial and local level governments and authorities to ensure implementation and compliance with environmental conservation strategies and programs.

Mining Act 1992

This act provides the regulatory framework for mining in PNG, excluding petroleum extraction, which is regulated under the Petroleum (Submerged Lands) Act 1967. The Mining Act defines minerals to include "all valuable non-living substances excluding petroleum obtained or obtainable from land" (Section 2). This includes not only precious metals and gems, but also minerals obtained from quarries and alluvial mining activities such as river gravel, hard rock, limestone and so on. The act also

[249] Food and Agriculture Organization of the United Nations. Environment (Permits) Regulation 2002. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC070630/. Accessed 20/09/2023.

[250] Food and Agriculture Organization of the United Nations. Environment (Prescribed Activities) Regulation 2002. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC070631/. Accessed 20/09/2023.

regulates the various types of mining tenements (exploration licenses, special mining leases, mining leases, alluvial mining leases, mining easements etc.).[251]

Section 5 of the act provides for the State's ownership of all minerals on or below the land:

(1) All minerals existing on, in or below the surface of any land in Papua New Guinea, including any minerals contained in any water lying on any land in Papua New Guinea, are the property of the State.

Furthermore, Section 6 states that:

All land and water is available for exploration and mining and the grant of tenements over it.

One significant provision within the Mining Act is the requirement that tenement holders must not enter or occupy land until an agreement has been reached with landholders regarding compensation arrangements (Section 155). Once the terms of the agreement have been reached, a copy must be sent to the Chief Warden.

Section 9 of the act dealing with alluvial mining provides for the right of individuals to carry out non-mechanized mining of alluvial deposits on land they own, provided it is carried out safely in accordance with the Mining (Safety) Act 1977 and that the land is not the subject of an already allocated tenement, with the exception of an exploration license.

Mining Regulation 1992

The Mining Act 1992 is implemented through the Mining Regulation of the same year. Among other things, it regulates the application process for tenements, including extensions of term, surrender of tenements, description of boundaries, applying for the right to enter land, bi-annual exploration and expenditure reports, monthly reports, and fees.[252]

Land Act 1996 (last amended 2006)

The Land Act regulates the acquisition of land by the state and the alienation or lease of land for public purposes. Among other things, the act defines public purposes to include establishing a coronus pit or a quarry (Section 2 (1)).[253] Division 2 of the act (Section 7) states that the Minister may, on behalf of the State, acquire land by agreement or by compulsory process. In such circumstances, landholders are entitled to compensation (Section 14).

3.9.5 The Institutional and operating framework

Mineral Resources Authority

The Ministry of Minerals and Energy manages all minerals and petroleum deposits in the country. The ministry's operations and oversight functions are vested in the MRA. The MRA regulates and manages the mining industry to maximize export revenue for PNG. It is responsible for industry regulation, including the issuance of exploration and mining permits. The MRA also plays an important role in managing stakeholders' (especially customary landowners and mining/exploration companies) expectations as some mining leases encroach on customary land and in most cases mining

[251] Food and Agriculture Organization of the United Nations. Mining Act 1992. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC052513/. Accessed 20/09/2023.

[252] Food and Agriculture Organization of the United Nations. Mining regulation 1992. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC052514/. Accessed 20/09/2023.

[253] Food and Agriculture Organization of the United Nations. Land Act 1996. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC020843/. Accessed 10/09/2023.

operations affect the local communities. MRA also conducts scientific surveys and exploration to better understand the geology and the mineralogical distribution of PNG.

MRA is responsible for administering the Mining Act 1992, Mining (Safety) Act 1977, and Mining (Ok Tedi Continuation Agreement) Act 2001. It is also responsible for the issuance and monitoring of mining leases for both metal and non-metal mining operations. Different types of mining leases are outlined in Table 26 below.

There is no publicly available information regarding the regulation of the quarrying sector in PNG. However, there are commercial companies that own and operate quarries around Moresby and other parts of PNG.

Although it would seem that the management and regulation of all quarry works would fall under the mandate MRA, recent correspondence with a senior MRA staff official revealed that the Authority only regulates quarries associated with its mining tenements and so does not have a database of quarries and aggregate resources. The vast bulk of data are apparently held by the Department of Works and Highways.

There is no mention of river gravel or sand extraction on the MRA's website but recent media sources indicate that the MRA is responsible for permitting and regulating sand mining operations. For example, in 2020 a Singaporean company was licensed by MRA to carry out sea sand mining on a stretch of coast spanning 51 km in Madang province.[254] In this case, the project was opposed by residents on the grounds that it would impact coastal communities and the environment, including the nesting grounds for the endangered leatherback turtle.[255] Eventually, the company withdrew its application. The case has prompted the government to consider developing a policy for proposals to mine and export sand. Meanwhile, the community is reportedly working in partnership with nongovernment organizations to develop their own sand mining regulation policy, which they intend to present to the government.

Table 26: Mining Lease Categories

Type of permit/Lease	Description
Exploration License (EL)	This permit is issued for mineral exploration purposes. The permit may be granted for a term not exceeding two years, which may be extended for a maximum of 2 years.
Mining Lease (ML)	This permit is issued for small to medium-scale alluvial mining and hard rock mining operations. The permit may be issued for a period of 20 years, and it can be extended for a period not exceeding 10 years. The maximum area for ML is 60 km^2. A Mining Lease for hard rock resource development can be held 100% by a foreign entity.
Special Mining Lease (SPL)	A special Mining Lease is issued to the EL holder for large scale mining. Extensive stakeholder engagement must be conducted to ensure all parties affected by the mining operations such as the SML applicant, landowners, government officials and the local community. Once all parties are satisfied with the project, then the Minister can grant the SML. SML can be granted for 40 years, with a possible extension of up to 20 years.
Alluvial Mining Lease (AML)	This lease is granted to citizens or land groups. This lease cannot be granted over land that is the subject of an existing tenement unless the existing tenement is EL or a Mining Easement. AML is issued for a period of 5 years with a possible extension of the period not exceeding 5 years.
Mining Easement	This lease is primarily for easements for infrastructure that supports a mining project. This may include such land where roads, railways, powerlines, waterways and pipelines are to be established.

Source: PNG Mining Act 1992, Mining Regulations 1992

[254] Global Greengrants Fund (2022). Challenging Sea Mining Projects in Papua New Guinea. 23 May. https://www.greengrants.org/2022/05/23/challenging-sand-mining-papua-new-guinea/. Accessed 20/09/2023.

[255] Koma. M.T. (2021): *Mining Sand, Focusing on Orokolo Bay Sand Mining Project in Papua New Guinea, A Desktop Review for Makata*. Papua New Guinea.

Ministry of Environment and Conservation and Climate Change

The Ministry of Environment and Conservation and Climate Change through the PNG Conservation and Environment Protection Authority (CEPA) manages and protects natural and physical resources to sustain environmental quality and human well-being. CEPA derives its mandate from the Environment Act 2000 which provides for the protection of the environment from environmental harm and the regulation of the environmental impact of development activities. CEPA regulates and administers all environmental issues including assessing and issuance of environmental permits relating to mining operations. Therefore, before a quarry license is issued, an environmental impact assessment must be undertaken to ensure that the operations will have minimum impacts on the environment.

Department of Works and Highways

The Department of Works and Highways (DoWH) is the key policy advisor to the government on matters relating to roads and acts as the sole road authority for the National Road Network (NRN).[256] The department draws its mandate from the Road (Management and Fund) Act 2020. The Department is responsible for maintaining around 8,700 km of the NRN. Through its activities, the DoWH is one of the largest consumers of aggregates in the country. In compliance with the Environment Act 2000, DoWH is required to identify activities such as road works quarries, stockpiles, storage, and disposal sites, among others and determine their possible impact on the environment.

Also, the DoWH, as the sole Roads Authority for NRN, is responsible for administering tenders for various projects. However, under each specific project, the contractor, with the approval of the supervising engineer, is responsible for the acquisition, operation and maintenance of quarries including any royalty payments to landowners.

3.10 Samoa

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Samoa	**Medium-High (TBC)** A new national infrastructure plan has not been released following the 2011 5-to-10-year plan. The Apia Port upgrade project which has required significant volumes of aggregate is also scheduled for completion soon. However, a new Transport Infrastructure	- Hard rock (basalt) - Sand	**Medium** 2020–2022 imports: ~546 tons 2020–2022 exports: 0 tons[257] Excellent basalt resources which appear to be largely sufficient to meet current demand, though ~546 tons of aggregate (mostly gravel / 'pebbles') imported in the last 3 years.

[256] Department of Works and Highways. https://www.works.gov.pg/. Accessed 20/09/2023.

[257] UN Comtrade data report a negligible quantity of exports at 61 kg.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	Plan has been developed and identifies several major projects which will require large volumes of aggregate.		

3.10.1 Geography and geology

Samoa, officially known as the Independent State of Samoa and, until 1997, known as Western Samoa, is a Polynesian island northeast of Fiji. Samoa is comprised of two main islands, Savai'i and Upolu, two smaller islands, Apolima and Manono, and several uninhabited islets Figure 63. Upolu and Savai'i are the main islands and account for 99 per cent of Samoa's population (201,000).[258] Samoa's Islands lie between 14° 10' and 13° 20' S latitude and 171° 20' and 172° 50' W longitude. Its total land area is approximately 2,750 km^2 of which only Upolu is just over 1,100 km.[259]

Figure 63: Map of Samoa

Source: Encyclopedia of New Zealand

[258] Department of Foreign Affairs and Trade. Samoa Country Brief. https://www.dfat.gov.au/geo/samoa/samoa-country-brief. Accessed 06/09/2023.

[259] Richmond, B. (1998). Coastal Morphology, Shoreline Stability and Nearshore Mineral Resources of Upolu, Western Samoa. *SOPAC Miscellaneous Report* 111.

The Samoan islands are part of a 1,200 km-long volcanic chain produced by the Pacific Plate bending and rupturing with subduction at the Tonga Volcanic Arc.[260] The islands display a low variety of geological and geomorphological features. The geological history of Samoa is represented in six periods of volcanic processes from the Pliocene through to the Holocene, including Fagaloa Volcanics, being the oldest, Salani Volcanics, Mulifanua Volcanics, Lefaga Volcanics, Puapua Volcanics, and the youngest, Aopo Volcanics. All periods of volcanic processes are presented mostly by olivine basalts (Table 27).[261]

Table 27. Summary of the Different Geological Units that Occur in Upolu and Savai'I Islands

Volcanic Formation/Unit	Approximate Age	Description
Fagaloa Volcanics	Pliocene to Mid-Pliocene	olivine basalt, feldspathic basalt, hornblende andesite and trachyte
Salani Volcanics	Early to Mid-Pleistocene	olivine basalt, feldspathic basalt, hornblende andesite and trachyte
Mulifanua Volcanics	Last glacial period	olivine basalts, and dolerite to analcite basalts.
Lefaga Volcanics	Early Holocene	picrite basalts and dolerites.
Puapua Volcanics	Middle to Late Holocene	picrite basalts, olivine basalts and vitric tuff.
Aopo Volcanics	Last 200 years	ropy, vesicular, porphyritic (feldspar and olivine) basalts.
Alluvium	Holocene to Present Day	Volcanic rocks as river gravel deposits, finer-grained sand and gravel along the costal zones.
Vini Tuff	Last Interglacial	Tuff cones in shallow waters
Coral Reefs	Quaternary to Present day	This unit consists of emerged reefs, present day reefs, lagoon deposits or beach deposits

Source: Tawake and Talia, 2007

3.10.2 Summary of aggregate extraction sites and known sources

As illustrated in Table 27, volcanic rocks are the main source of aggregates in Samoa. These deposits are available in in-situ hard rock form, river gravel deposits and may also occur along coastal zones as finer-grained sand and gravel. Only recently private aggregate extraction companies have ventured into marine sediment dredging. The aggregate material that occurs in the lagoon areas is a combination of terrestrially derived sand and gravel, and coral reefs and other deposits including marine organisms (foraminifera, halimeda) and shells.[262]

There is no public access to any databases of existing regulated/unregulated extraction sites. Previous aggregate assessment studies have reported on potential aggregate sources and extraction sites on both main islands, Savai'i and Upolu. The consultants compiled a database of these sites based on aggregate resource assessment studies and technical reports undertaken by the SOPAC. Based on the nature of the deposits and extraction methods, the sites can be organized into three categories: basalt hard rock quarries, river extraction sites, and lagoon dredging sites.

As of 2019, there were 12 potential quarry sites across Upolu Island. Information provided on the Preliminary Environmental Assessment Report of Apia Port, shows that only two quarries had development consent from the Planning and Urban Management Agency (PUMA) (licensed to three

[260] Richmond, B. (1998) Coastal Morphology, Shoreline Stability and Nearshore Mineral Resources of Upolu, Western Samoa. *SOPAC Miscellaneous Report* 111.

[261] Tawake, A. and Talia, L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'I Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[262] Ibid.

operators) namely: Saleimoa licensed to Ott Construction and ACP construction, and Faleolo (near Mulifauna Wharf) licensed to Downer.[263] A third quarry, Lauli'i was recently issued a development consent. The quarry is being run by China Harbour Engineering Corporation.

Table 28 provides a summary of all known aggregate resources in Upolu and Savai'i Islands as of 2007. We caution, however, that some of the sites may have been fully exhausted of resource or have not proven viable since then. A request for current quarries and aggregate resource locations was made to PUMA but as of the time of writing, this information had not been sent.

Table 28. Summary of Known Aggregate Sources and Extraction Sites

Location	Type	Activity	Description
		Upolu Island	
Vaiusu Bay	Lagoon/ Coastal	Dredging (current status known)	The dredging operations in Vaiusu Bay have been going on for more than 30 years. The first survey of this site conducted in 1987 by SOPAC was followed by a second survey in 1995,[264] which identified alternate sand and aggregate resources in Vaiusu Bay estimated at approx. 3 million m^3 of sand and gravel. A third SOPAC report was published in 2007 reporting on the quality of the sediment at Vaiusu Bay.[265]
Western Upolu	Reef Platform	Potential dredging site	Reef platform bordering western Upolu and surrounding Manono Island, composed of intertidal and shallow subtidal reef flats, fringing reefs, shallow mats, and deep depressions of the hack-reef lagoon. Estimated reserves of 1,700,00 m^3 of carbonate sand and gravel deposits suitable for construction occur on the reef platform.[266]
Mulifanua Wharf	Natural Lagoon Environment	Potential deposit	Natural lagoon environment bounded by fringing reefs and shorelines. Sediment dredging started in early 2004 to facilitate boat services between Upolu and Savai'i.[267] Faleolo Quarry (licensed to Downer) was as of 2019 operating at Malifanua Wharf.
Aleipata Wharf	Natural Lagoon Environment	Potential deposit	Located in eastern Upolu, comprised of shallow lagoon areas to the north and south of the wharf. It has been identified as a potential dredge site that can supply the demand for sand in Apia and nearby areas. A deposit of carbonate (coral) sand and gravel on the north side of the existing wharf, estimated to contain approx. 100,000 m^3.[268]
Lauli'i-Solosolo outcrops	On-land aggregate deposit	Active quarry – scoria, sand, crushed basalt	Located in the northeastern coast of Upolu, these outcrops comprise mostly olivine-rich basaltic lava flows (Fagaloa Volcanics formations). The best two outcrops are found

Source: see footnotes

[263] Samoa Ports Authority. (2019). Enhancing Safety, Security and Sustainability of Apia Port: Initial Environmental Examination. https://www.adb.org/projects/documents/sam-47358-002-iee. Accessed 06/09/2023.

[264] Smith, R., Young, S. & Talia, L. (1995). Sand and Aggregate Resources Vaiusu Bay, Apia, Western Samoa. *SOPAC Technical Report* 223.

[265] Tawake, A. and Talia L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[266] Richmond B. M. & Roy P.S. (1989). Sedimentologic and Bathymetric Studies of Offshore Apolima and Manono Islands, Western Samoa. *CCOP/SOPAC Technical Report* 64

[267] Tawake, A. (2007). Samoa Country Mission and Technical Advisory Report: Aggregate Assessment in Selected Parts of Savai'I and Upolu Islands. *EU EDF* 8 – *SOPAC Project Report* 77, Reducing the Vulnerability of Pacific ACP States.

[268] Lewis, K.B., Hill P.J., Main, W. de L. & Mitchell J.S. (1989). Summary of Lagoonal Sand and Aggregate Deposits of Eastern Upolu and Eastern Savai'I, Western Samoa. *CCOP/SOPAC Technical Report* 95.

Location	Type	Activity	Description
			between Namo Village and Cape Utumanu'u. These massive outcrops exhibit a 40:60% waste to aggregate ratio with an average 120 m of horizontal distance and 30 m height. Site is close to Apia and the surrounding areas, but due to the close proximity to the main highway, these outcrops could be difficult to exploit.[269] However, there could be other prospective outcrops at some distance from the highway and nearby village. Information from March 2023 indicates there is now a quarry at Lauli'i which began operations in 2022.[270]
Lemafa Quarry	Hard rock quarry	(Possibly) active quarry operation	Found inland in the Lemafa area. Rocks are comprised of Fagaloa and Salani volcanics. These outcrops are composed mostly of lava flows and with little volcanic breccia components. The best outcrops are found at the Lemafa Quarry, due to overburden clearance and rock extraction at the site. The large outcrop exhibits a 5:95 waste to aggregate ratio. It is close to the inland road, but at considerable distance from the capital, Apia. Rocks exhibit excellent strength, and the outcrop could support medium to large-scale operations.[271] Quarry was not operational as of date of last report in 2013.[272]
Tuialemu Quarry	Hard rock quarry	(Possibly) active quarry operation	The Tuialemu Quarries 1 and 2 are located southeast of Upolu. Most of the rocks that occur on this part of the island are Salani Volcanics and some of the aggregates sourced here were used during the upgrading/sealing of the main road. Quarry 1 is inactive since the completion of the road-sealing project. Quarry 2 was s still active (2007), but on a small-scale operation. These outcrops exhibits a 50:50% waste to aggregate ratio.[273]
Alafua Quarry	Hard rock quarry	Active quarry operation	There are good aggregate sources suitable for building and road construction, as well as weak to moderately strong material used in road-sealing chips.[274] The Quarry did not have PUMA approval as at March 2023.[275]
Saleimoa Quarry	Hard rock quarry	Active quarry operation	Aggregate sources at Saleimoa quarry are stronger and more durable compared with the ones at Alafua, making them a better source of sand and gravel for construction purposes.

Source: see footnotes

[269] Tawake, A. (2007). Samoa Country Mission and Technical Advisory Report, Aggregate Assessment in Selected Parts of Savai'i and Upolu Islands. *EU EDF* 8 – *SOPAC Project Report* 77, Reducing the Vulnerability of Pacific ACP States.

[270] ADB (2023). Independent State of Samoa: Enhancing Safety, Security, and Sustainability of Apia Port Project. Quarterly Progress Report No. 13 QPR for the reporting period 1 January 2023 to 31 March 2023. Available https://www.adb.org/sites/default/files/project-documents/47358/47358-002-eapr-en_9.pdf Accessed 14/03/2023.

[271] Ibid; Tawake, A. and Talia L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[272] Tonkin and Taylor (2013). Quarry Assessment West Coast Road Project. Draft Report. Land Transport Authority.

[273] Tawake, A. and Talia L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[274] Ibid.

[275] ADB (2023). Independent State of Samoa: Enhancing Safety, Security, and Sustainability of Apia Port Project. Quarterly Progress Report No. 13 QPR for the reporting period 1 January 2023 to 31 March 2023. Available https://www.adb.org/sites/default/files/project-documents/47358/47358-002-eapr-en_9.pdf Accessed 14/03/2023.

Location	Type	Activity	Description
Vaisigano River	River extraction	Potential deposit	Composed mostly of basaltic rock fragments, as well as marine-derived sediments. Strong and durable material, hence excellent sources of sand and gravel for construction. Large-scale extraction operation not feasible due to limited extent of the resource.[276]
		Savai'I Island	
Eastern Savai'I Lagoon	Natural lagoon environment	Potential Deposit	Lagoon deposits between Salelologa and Pu'apu'a in eastern Savai'i identified approximately 900,000 m^3 of good quality construction sand and gravel at the northern (Pu'apu'a) end of the lagoon. The material is a mixture of basaltic sand and gravel, eroded from the lava to the north, and carbonate sand and gravel from the reef. Hence, it may have better bonding qualities for bridge construction and other concrete work than pure carbonate deposits.[277]
Salelologa Harbour	Natural lagoon Environment	Potential Deposit	Located on the southeastern coast of Savai'i Island, surrounded by fringing reefs with a deeper channel linking the open ocean and the wharf that is used daily by passenger/cargo boats that operate between Upolu and Savai'i. Dredging operation was proposed to improve operational efficiency and service to Savai'i. There are limited sand resources within the harbour. However, there is vast sand deposits to the north part of the lagoon, right up to Puapua Village, but it is too shallow for dredge boat to access.[278] Relatively good quality carbonate sand and gravel. However, due to the high percentage of coral and shell constituents in the sediment composition it cannot be applied for construction applications that require high strength and durability.[279]
Puapua Quarry	Hard rock quarry	Active extraction	Located to the northwest of the Puapua Village, adjacent to the main highway. The Ministry of Works in Savai'i has previously used the aggregate extracted from this site for road upgrading and maintenance. The outcrop consists of approximately 40% fresh rocks and 60% moderately to highly weathered basalt lava band. The fresh rock can be developed to supply good quality aggregate. However, it cannot support a large-scale quarry operation.[280]
Old Papua Quarry	Hard Rock Quarry	Inactive	Inland to the west of the active Puapua Quarry. Can be accessed from an inland gravel road.[281]
Vaisala Quarry	Hard Rock Quarry	Active	Located near the village of Vaisala in northwestern Savai'i. The quarried outcrop is part of the Mulifanua Volcanics that occurs extensively on the western part of the island. Rock boulders from this site have been used for coastal defenses along Vaisala and Sataua villages. This rock

Source: see footnotes

[276] Tawake, A. and Talia L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[277] Lewis, K.B., Hill P.J., Main, W. de L. & Mitchell J.S. (1989). Summary of Lagoonal Sand and Aggregate Deposits of Eastern Upolu and Eastern Savai'I, Western Samoa. *CCOP/SOPAC Technical Report* 95.

[278] Tawake, A. and Talia L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

[279] Ibid.

[280] Ibid; Tawake. A. (2007). Samoa Country Mission and Technical Advisory Report, Aggregate Assessment in Selected Parts of Savai'I and Upolu Islands. *EU EDF* 8 – *SOPAC Project Report* 77, Reducing the Vulnerability of Pacific ACP States.

[281] Tawake, A. and Talia, L. (2007). Samoa: Technical Report on Aggregate Source Assessment in Selected Parts of Upolu and Savai'I Islands. *EU EDF* 8 - *SOPAC Project Report* 74, Reducing Vulnerability of Pacific ACP States.

Location	Type	Activity	Description
			exhibits moderate strength and can be an excellent source of sand and gravel used for construction.[282]
Mali'oli'o River	River Aggregate	Small-scale, Individual extraction activities	The Mali'oli'o River runs on the eastern side of Samalaeulu Village. The rock boulders, cobbles and pebbles that occur in the river are predominantly volcanic in origin. The sand in the river revealed that it is largely made up of volcanic rock fragments with minor components of volcanic glass, and felsic and mafic minerals. The sand and gravel at this site is generally used for domestic construction in Samalaeulu and neighboring villages. While the sand and gravel at this site can be used for construction, the limited resource volume is the major constraint to a larger extraction operation.[283]
Vailoa River	River Aggregate	Proposed small-scale sand extraction	The Vailoa River is situated to the west of Salelologa, and just to the west of Vailoa Village. The geology of the river catchment is predominantly made up of the Salani and Mulifanua Volcanic formations. Therefore, it is presumed that the composition of sand and gravel in the river channel and in the immediate vicinity of the river mouth is dominated by volcanic rock fragments.[284]

Source: see footnotes

Discussions with infrastructure contractors during fieldwork in September 2023 indicate that they have difficulty obtaining aggregate unless they own a quarry. If they do not, they must sub-contract those who do. However, this sometimes leads to issues with poor quality aggregate, something that appears to be a processing, rather than issue with the type of material. In the case of river gravel, extraction usually only occurs in the dry season given the risk of flash flooding during the rainy season and risk of bank collapse. The Ministry of Natural Resources and Environment has sought manage this risk by establishing a bank stabilization project to prevent landslides.

3.10.3 Aggregates required infrastructure development

In 2011, the Ministry of Finance published Samoa's NIIP which set out the priorities and strategies of the government for initiatives in the infrastructure sector over a 5- to 10-year period. The plan prioritized major infrastructure initiatives across four focus areas, energy, telecommunications, water and waste related services, and transport.[285] The plan aimed to identify key development directions that aligned with the national goals and which would deliver the most benefits to communities. Some examples of projects that were committed to procced in 5 years following release of the plan included: On-grid Solar Generation (ST50 million/$22 million),[286] Samoa, Sanitation and Drainage Project, SSDP II (ST43 million/$18.92 million), all-weather roads for Savai'i and Upolu Islands (totaling ST80 million/$35.2 million), upgrade of Faleolo Terminal (ST32 million/$14.08 million). Currently, it is not known how many of these projects were fully developed.

Although the period of the plan has now expired, the government is currently implementing several other infrastructure projects not identified in the NIIP, such as the Apia Port upgrade, financed with around $87.8 million provided by ADB and other sources. This project has required significant

[282] Ibid.

[283] Ibid.

[284] Ibid.

[285] Government of Samoa. (2011). Samoa National Infrastructure Strategic Plan. https://www.theprif.org/document/samoa-national-infrastructure-strategic-plan. Accessed 7/09/2023.

[286] Average annual conversion rate in 2011 was ST1 = $0.44, so ST50 million = ~$22 million.

quantities of aggregate, sourced from local quarries, but is scheduled for completion in March 2024.[287]

The government has also recently released a Transport Infrastructure Sector Plan (2023–2028), which identifies several large, high-cost projects, each of which will require significant quantities of aggregate in the coming years, for example:

- Development of Faleolo International Airport - $12.4 million
- Reconstruction of the existing breakwater and implementation of a wave monitoring system at Apia Port - $21.16 million
- Rehabilitation works for the Alafaalava Road (Aleisa), starting in 2025 - $29 million
- Rehabilitation Works for the Central Cross Island Road (Apia to Siumu) - $24.44 million
- Rehabilitation works for stabilization of slopes on the East Coast Road (Letogo to Saluafata) – $7.5 million

PRIF has identified key projects for Samoa for consideration by various bilateral and multilateral agencies. These projects are summarized in Table 29, which also includes an initial assessment of the likely level of aggregate demand (from Low to High) for each project.[288]

Table 29. Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members and Predicted Aggregate Demand

Sector	Project Name	Budget ($M)	Aggregate Demand	Assumptions
Energy	Alaola Multipurpose Dam Project	85	High	Requires high volumes of concrete and steel.
Energy	Smart Grid Project (standby)	14	Low-Medium	TBC pending project details
Urban Development	Savalolo Market	10	Low-Medium	Requires low-medium volumes of concrete, cement depending on the size of the market.
Total		**95.0** (not including TA)		

TA = technical assistance, TBC = to be calculated.

Source: Samoa National Infrastructure Strategic Plan; PRIF, 2023

3.10.4 Overview of the legal and policy framework

Land and resource ownership

The Constitution of the Independent State of Samoa classifies land in three categories: customary, freehold, and public land. Most of the freehold land, which constitutes around 12% of Samoa's land, is located in the capital, Apia and the surrounding urban area. Public land, which constitutes 7% of Samoa's land, is defined as land that is free from either customary or freehold title and is administered by the Land Board. More than 80% of land is customary, which is protected by the constitution for the "customs and usage" of the people of Samoa and is held in the name of a particular title holder

[287] Samoa Ports Authority. (2019). Enhancing Safety, Security and Sustainability of Apia Port: Initial Environmental Examination. https://www.adb.org/projects/documents/sam-47358-002-iee. Accessed 06/09/2023.

[288] Pacific Regional Infrastructure Facility. (2023). PRIF Infrastructure Pipeline Projects. Internal report.

(matai) who has the authority over the land. The matai determines how the land is distributed among family members and their use.[289]

Land acquisition and access

Unlike freehold and public land, customary land is outside the scope of the land registration system and cannot be conveyed or mortgaged. However, it can be alienated through the following laws and regulations:

The Taking of Land Act 1964

This act allows for the alienation of freehold and customary lands for "public purposes". After land is identified for acquisition, notice is given to the owner (in the case of freehold land) or the matai in the case of customary land. Public notice of 28 days is allowed for any objections and if no written objection is received, the Minister then proceeds to take the land by Proclamation. The land taken must be registered as public land in the Land Registry and a public record administered by the Division of Land Management in the Ministry of Natural Resources and Environment.[290]

Based on Division 1 (Section 11), the State has the power to take any land for purposes of developing a gravel pit or quarry to be used in connection with the carrying out of public purposes. However, the act does not authorize the extraction of stone/gravel or any earthmoving activities for sale without the consent in writing of the owner.

According to Division 1 (Section 12), the act does not authorize the taking of land occupied by any building, yard, cemetery, burial ground, or in bona fide occupation as an ornamental park or pleasure ground, without the consent of the owner.

Alienation of Customary Land Act 1965

In accordance with Section 4 of the Alienation of Customary Lands Act 1965, customary land can only be alienated by the Minister of Lands, who acts as trustee for the owners and grants the lease or license of customary land for authorized purposes (public, commercial, business, or religious uses) to an individual and corporation. The act requires the Registrar of Lands to register the lease in the Land Registry.[291]

Policies

Pathway for the Development of Samoa 2021–2026

The Pathway for the Development of Samoa is a policy document that aims to guide Samoa's social and economic development.[292] The plan focuses its work on 11 key priority areas. The plan also points out the crucial role of infrastructure in achieving the outcomes set out for Samoa's social development and economic growth by providing access to services and social and economic

[289] Grant, C. (2008). Land for Public Purpose: Accessing Land for Public Purposes in Samoa. In *Making Land Work Volume 2*. https://www.dfat.gov.au/about-us/publications/Pages/making-land-work. Accessed 7/09/2023.

[290] Food and Agriculture Organization of the United Nations. Taking of Land Act 1964, Samoa. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035510/. Accessed 07/09/2023.

[291] Food and Agriculture Organization of the United Nations. Alienation of Customary Lands Act 1965, Samoa. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035512/. Accessed 07/09/2023.

[292] Food and Agriculture Organization of the United Nations. Pathway for the Development of Samoa FY2021/22–FY2025/26. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC219207/. Accessed 07/09/2023.

opportunities. Table 30 shows how infrastructure demand contributes to each of the key priority areas described in the plan, and indirectly the link between aggregate extraction and development.

Table 30. Summary of the Key Strategic Outcomes and Priority Areas Outlined in Samoa's Development Plan 2021–2026

Key Strategic Outcome (KSO)	Key Priority Areas	Assumed Infrastructure Required to Meet Targets
KSO 1: Improved Social Development	Water and Sanitation, Health and Medical Services, Education, Housing	Construction of water treatment plants, dams or reservoirs, construction of sewage plants and other water supply projects. Construction of healthcare centers, schools, training centers, and climate-resilient housing.
KSO 2: Diversified and Sustainable Economy	Tourism, Business Innovation and Growth, Community Development, Enhanced Rural Economy (Agriculture, Fisheries and Aquaculture)	Construction of markets and economic zones. Increased connectivity through the construction of roads, airport and ports or upgrade of existing infrastructure. Construction of hotels, cultural heritage centers.
KSO 3: Security and Trusted Governance	Improved Accountability, Dynamic Global Relations, and Partnerships	Construction of police stations, court complexes, public spaces. Increased relations with other Pacific Islands.
KSO 4: Secure Environment and Climate Change	Energy, Enhanced conservation and sustainable use of Natural Resources, Climate Resilience	Construction of hydro dams, solar systems and other renewable energy structures and foundations. Construction of climate-resilient housing. Coast protection infrastructure.
KSO 5: Structured Public Works and Infrastructure	Energy, Water, Transport, Communication and Technology	Upgraded and new transport systems and network. Construction of water treatment plants, sewage, and other water supply projects for access to clean water and sanitation. Installing fiber cable across the islands for increased connectivity and access to information. Construction of hydro dams, solar systems and other renewable energy structures and foundations.

(Source: Pathway for the Development of Samoa FY2021/22–FY2025/26)

Climate Change Policy 2020

This policy addresses Samoa's action plan and mitigation strategies needed to build resilience to the impacts of climate change. Like other Pacific countries, Samoa faces the risk of increased extreme weather events including tropical cyclones. Aggregates play a crucial role in both pre- and post-disaster due to natural hazard management plans.[293] Suitable aggregates are required for durable infrastructure and housing. Aggregates are also required to support Samoa's vision of an efficient, accessible, and affordable renewable energy sector.[294]

[293] Rogers, P. et al. (2023). *Building Disaster and Climate Resilience through Development Minerals*. Brisbane: The University of Queensland. [Building disaster and climate resilience through Development Minerals - UQ eSpace.]

[294] Food and Agriculture Organization of the United Nations. Samoa Climate Change Policy 2020. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC202477/. Accessed 7/09/2023.

Legal framework for the aggregates sector

Lands, Surveys and Environment Act 1989

This act sets out the framework for the alienation of government land, land administration and other matters such as environmental protection and management of coastal zones. It allows the Minister to approve the purchase of any land for public purpose (section 23) or lease government land for up 20 years (section 37). Also, it describes the key functions of the Ministry of Natural Resources and Environment (MNRE) which include reviewing and advising on the potential environmental impacts of any public or private development proposals and advocating for environmental conservation.[295]

Planning and Urban Management Act 2004

This act provides the framework for the planning, use, development, management and protection of land and its resources. In Samoa, all development projects require Development Consent (section 34), which must be obtained before a project starts. In most cases, an EIA is also required when applying for Development Consent. Section 42 of the act describes the circumstances in which an EIA is required and the process which must be followed.[296]

Other key parts of the act cover the following:

Part 4 – The Board prepares a Sustainable Management Plan setting out how land is to be developed/conserved to achieve the objectives of the act.

Part 6 – Deals with development assessment and compensation to owners and occupiers of land.

Forestry Management Act 2011, Marine Pollution Prevention Act 2008, Maritime Zones Act 1999, Water Resources Management Act 2008

These laws target the environmental impacts of developments and provide the frameworks for the conservation and sustainable management of natural and ecosystem resources.[297]

Environmental Impact Assessment Regulations 2007

The EIA is the most important policy in determining whether a potential development project can be carried out. The EIA regulations describe in detail the level of EIA required for a development, the components required, and the process for review and approval.[298]

Depending on the scale and potential environmental impacts of a proposed development, there could be two forms of EIA (s4):

(i) The Preliminary Environmental Assessment Report, which is required when a development is not likely to have significant adverse impacts on the environment.

[295] Food and Agriculture Organization of the United Nations. Lands, Surveys and Environment Act 1989. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC037633/. Accessed 7/09/2023.

[296] Food and Agriculture Organization of the United Nations. Planning and Urban Management Act 2004. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC051784/. Accessed 7/09/2023.

[297] Secretariat of the Pacific Regional Environmental Programme (SPREP) and EDO NSW. (2018). *Samoa: Review of Natural Resource and Environment Related Legislation*. https://samoa-data.sprep.org/system/files/sprep-legislative-review-samoa.pdf. Accessed 7/09/2023.

[298] Ministry of Natural Resources and Environment. (2019). Samoa Pacific Resilience Program, Operations Manual Section 10: Safeguards. https://www.mnre.gov.ws/wp-content/uploads/2021/03/PREP-OM-Section-10-Safeguardfinxx1SS3-March-2021-002.pdf. Accessed 7/09/2023.

(ii) The Comprehensive Environmental Assessment Report, which is required when a development is likely to have significant adverse impacts on the environment.

The regulations also outline baseline and compliance monitoring, reviews of the EIA, and public processes for consultation.

Once completed, the development consent application and the EIA including final site plans, certified survey plans, written consent from property owners, lease agreements, deeds of conveyance and a fee, are sent to PUMA for a review. First, the EIA is open for public comment before a final recommendation is made to the PUMA Board. The board may then approve (with or without conditions) or decline the application.

Policies - extraction site regulations and monitoring

Codes of Environmental Practice

Samoa's Codes of Environmental Practice (COEP) set out methods and procedures that must be followed to avoid or mitigate the adverse environmental impacts of different development projects.[299] PUMA personnel monitor the implementation of these COEP and specific mitigation controls set out in the development consent conditions. The following COEPs are relevant to mineral extraction projects:

COEP 3, Consultation - defines the guidelines on how the communities and stakeholders should be advised and how to properly carry out public consultations.

COEP 4, Land Acquisition and Compensation - states that land acquisition must be minimized and it must be carried out in accordance with the guidelines in order to minimize any adverse impacts on the affected communities.

COEP 8, Quarry Development and Operations - describes the safety requirements for development and operation of quarries and mitigation controls against environmental impacts. A quarry permit from PUMA is also required to ensure compliance with the code.

COEP 13, Earthwork - states that all earthwork activities must be conducted to avoid accelerated erosion, sedimentation, and disturbance of potential cultural resources.

3.10.5 The Institutional and operating framework

Ministry of Natural Resources and Environment

MNRE is the institution responsible for protecting and managing the environment and resources of Samoa. It is comprised of several divisions including the Disaster Management Office; Environment and Conservation; Forestry; Climate Change and Global Environment Facility; Land Management; Spatial Information Agency; Samoa Meteorology Division; Renewable Energy; and Water Resources.[300]

The Land Management Division of MNRE provides policy advice and management strategies for all land development and administration issues, which include the following:[301]

[299] MWTI. Samoa Codes of Environmental Practice. https://www.mwti.gov.ws/wp-content/uploads/2022/09/Final-Samoa-Codes-of-Practice_2007.pdf. Accessed 7/09/2023.

[300] Ministry of Natural Resources and Environment. https://www.mnre.gov.ws/. Accessed 7/09/2023.

[301] Ministry of Natural Resources and Environment. Land Management. https://www.mnre.gov.ws/about-us/divisions/land-management/. Accessed 7/09/2023.

1. Land Registry
    - Operate and maintain a central public registry for the registration of government lands; freehold lands in fee simple; customary land leases & licenses and other registrable instruments.

2. Government Land Administration
    - Receive and process applications for the leasing of government lands
    - Manage leases of government lands
    - Process payments of compensation to landowners for compulsory taking of lands for public purposes, in accordance with provisions of the Taking of Land Act 1964
    - Provides secretariat services for the Land Board

3. Customary Land Administration
    - Receive and process applications from beneficial owners for the leasing of customary lands
    - Administer customary land leases

4. Land Development
    - Provide policy advice on all issues relating to administration and development of lands and land-based resources
    - Receive and processes applications for sea reclamation and sand mining projects
    - Facilitate the monitoring and control of the illegal sand mining and sea reclamation operations

5. Land Evaluation
    - Carry out and provides land evaluation services to the government, corporations and general public.

Ministry of Works, Transport, and Infrastructure

The Ministry of Works, Transport, and Infrastructure (MWTI) is the institution responsible for the maintenance and management of public assets and infrastructure including regulation of construction projects, issuing building permits, drainage and storm water management, and development of road infrastructure and power lines. Also, MWTI is responsible for prevention of marine pollution and compliance with international agreements and treaties related to marine pollution.[302]

The Planning and Urban Management Agency

This is the MWTI division responsible for the enforcement of environmental regulations and reviewing EIAs and giving development approvals for proposed development projects. It administers the Planning and Urban Management Act 2004 and Planning and Urban Management (Environmental Impact Assessment) Regulations 2007. Under these guidelines, PUMA's key functions also include developing Sustainable Management Plans at national, regional, or site-specific levels; offering and leading public consultations; and offering development advice to public and private stakeholders.[303]

[302] Ministry of Works, Transport & Infrastructure. https://www.mwti.gov.ws/. Accessed 7/09/2023.

[303] Ministry of Works, Transport & Infrastructure. PUMA. https://www.mwti.gov.ws/puma/. Accessed 7/09/2023.

Most quarries are on customary and freehold land, which is administered by PUMA. However, there are several quarries without Development Consent in inland areas of Upolu that PUMA vehicles cannot reach and so these are not regulated. Examples include quarries inland along the south coast which only operate at night.

It is important to note that despite its excellent quality basalt, Samoa does not have a land use plan, which will limit expansion of the aggregates sector. However, Samoa has exported aggregate to nearby American Samoa and there has also been recent interest from Tuvalu to purchase aggregate. Nevertheless, one infrastructure donor representative stated that Samoa's is too small compared to countries like Fiji for it to become a major exporter to the region, without putting significant pressure on the environment.

3.11 Solomon Islands

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Solomon Islands	**High** The government's priority infrastructure pipeline of 2021 identified projects valued at \$368 million. It is not yet known whether the projects identified will go ahead but PRIF has identified eight large projects with a total value of \$264.5 million. As a result, it seems likely that aggregate demand will be substantial in the coming years.	- Limestone - River gravel / sand - Hard rock (volcanic)	**Low-medium** 2020–2022 imports: 26 tons 2020–2022 exports: 0 tons Almost all of the building materials permits issued are for river sand and gravel operations along the Lungga, Ngalibiu and Poha rivers, near Honiara with significant environmental and aggregate quality challenges. Hard rock resources (predominantly diorite) are available but will require substantial resources and capacity building to develop. Nevertheless, at least according to UN Comtrade data, Solomon Islands only imported around 26 tons of aggregate during the three-year period 2020–2022.

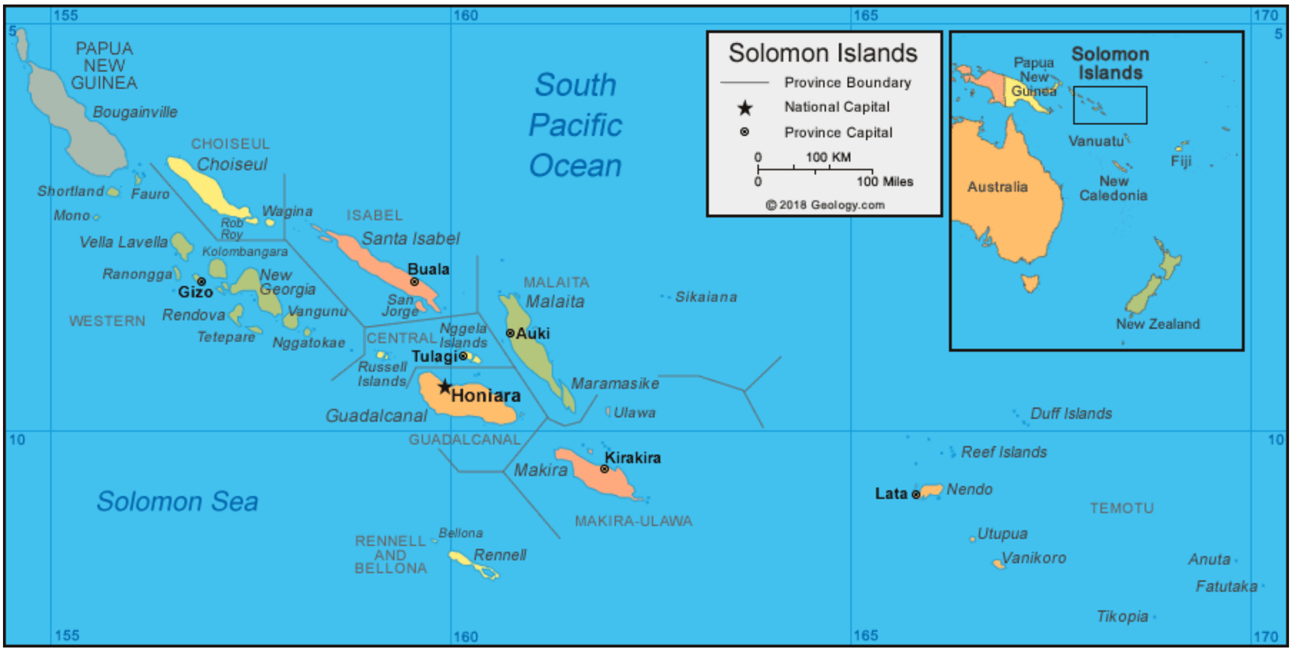
3.11.1 Geography and geology

Solomon Islands is comprised of more than 1,000 islands covering a land area of 28,230 km^2 that stretches from the Bismarck Archipelago in the northwest to Vanuatu in the southeast. The group of islands in the western and central part of the country form a 1,200 km-long northwest chain, comprised of the New Georgia Islands, Chiseul, Santa Isabel, Malaita, Makira, and Guadalcanal. The second group, which includes islands of the Santa Cruz group and the Outer Eastern Islands, are located 300 km to the east, at the northern end of the Vanuatu island chain (Figure 64).[304]

[304] Davies, H.L. (2009). Solomon Islands, Geology. *Encyclopedia of Islands*. University of California Press. London, UK.

Solomon Islands has a total population of 724,462 with around 169,721 living in the capital, Honiara, on Guadalcanal, the country's largest island.[305]

Figure 64: Map of Solomon Islands



Source: geology.com

The geology of Solomon Islands is dominated by andesitic affiliations, composed largely of lava and volcanically derived sediments. Table 31 provides a summary of the Honiara River Catchment (where most river extraction occurs) and its surrounding areas' geology from oldest rock formations to the latest reef limestone and back reef formations, where most of the potential sources of aggregates occur.[306]

Table 31. A Summary of the Geology of Honiara Catchment

Formation/ Rock Units	Age	Description
Koloula Diorite, Mbalisuna Gabbro	Plio-Pleistocene	Dioritic intrusive igneous rock occurs in the Poha River and the adjacent streams between the Lungga and Umasani Rivers, composed of hornblende and andesine, tonalite rock fragments.
Suta Volcanics/Limestone and Calcarenite/Conglomerates	Miocene	A sequence of biogenic limestone and calcarenites, of the Lower Miocene Mbetilonga Group, is regularly exposed in the headwaters of the Lungga River. Mbonehe Limestone crops is predominantly a poorly bedded, recrystallized, biomicrite or calcarenite that covers a large area peripheral to the Poha Diorite, and is extensively exposed in the Mbonehe and Kohove River.

Source: Department of Geological Surveys, British Solomon Islands Protectorate, 1969; Tawake, 2007

305 Ministry of Finance and Treasury, Solomon Islands National Statistics Office. https://solomons.gov.sb/rise-in-urbanization-as-growth-in-urban-centers-increase/. Accessed 11/12/2023.

306 Tawake, A.K. (2007). Solomon Islands Technical Report: Proposed Framework and Guidelines for Sustainable Aggregates Resource Development and Management in the Solomon Islands. *EU EDF 8 – SOPAC Project Report* 106, Reducing Vulnerability of Pacific ACP States; Department of Geological Surveys, British Solomon Islands Protectorate. (1969). The Geological Map of the British Solomon Islands, 2nd Edition, 1969, DOS (Geol) 1145A, 1:1,000,000.

Formation/ Rock Units	Age	Description
Toni Formation/Mbokokimbo Formation/Lungga Beds	Pliocene	Toni Formation is a sequence of volcanoclastic rudites and arenites with subsidiary pyroclastics, extrusives, and biogenic limestone. Extends from north-central Guadalcanal in the foothills zone between the Lungga and Mbokokimbo Rivers, the eastern end of the Guadalcanal Plains. Lungaa Beds is a succession of arenites and wackes derived primarily from volcanic sources, with subsidiary conglomerates, mudstone, and andesitic lava flows, covering ¾ of the western Guadalcanal.
Honiara Beds/ Longgu Beds/ Honiara Reef Limestones	Pleistocene	A sequence of well-stratified, rapidly alternating, volcanic arenites and rudites, with a generally high but variable carbonate content. About 400 m thick and extends from north-west to north central of the island. In the Honiara area, the Honiara Beds are capped by about 60 m of coral biolithites and derived debris, the Honiara Reef Limestones.
Coral Reefs/Alluvials/ Ngalimbui Alluvials	Recent	Dominate the East and East Central Coast of Honiara.

3.11.2 Summary aggregate extraction sites and known resources

In Solomon Islands, aggregates used for construction of roads and other infrastructure (buildings, ports and airports, etc.) include river gravel, coral deposits and limestone.

The Solomon Islands road network consists of 1,875 km of roads, only 6% of which are sealed. The rest of the network consists of gravel, coral, and earth-surfaced roads. The aggregates required for road construction are derived from two sources: river gravel and limestone deposits. Although, limestone deposits can be found in many of the islands, there are only a few that are economically viable sources of construction material. In Guadalcanal, there are two large limestone deposits located in the White River and King George VI areas in Honiara.[307]

Rivers are the major sources of sand and gravel aggregates used for domestic and commercial construction purposes. Although, there is a considerable amount of hard rock resources (volcanic rock and limestone) available, there are only a few small to medium sized quarry operations that mostly operate during short-term construction projects.

[307] Tawake, A.K. (2007). Solomon Islands Technical Report: Proposed Framework and Guidelines for Sustainable Aggregates Resource Development and Management in the Solomon Islands. *EU EDF 8 – SOPAC Project Report* 106, Reducing Vulnerability of Pacific ACP States.

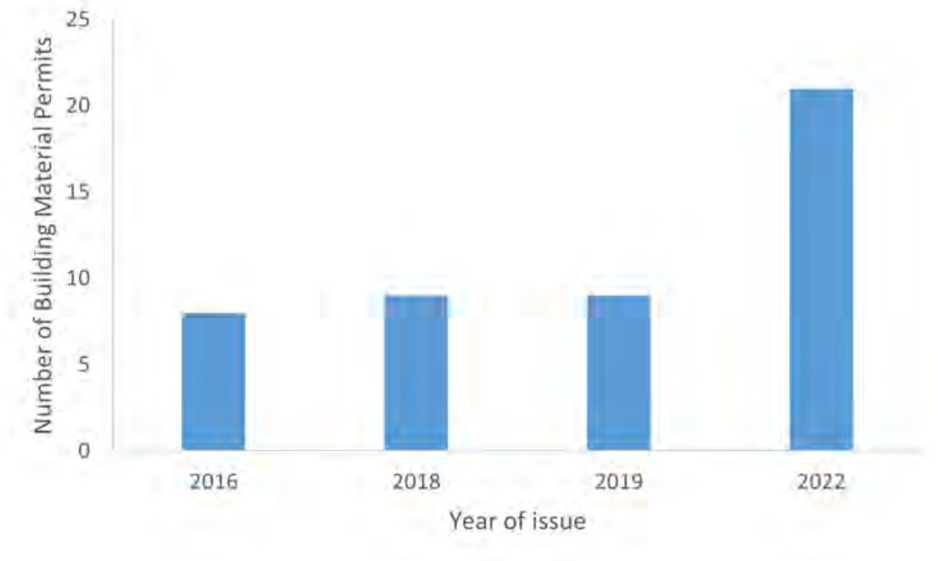
Figure 65: River Gravel Extraction Operation, Honiara

Photo credit: Daniel Franks, 2023

To overcome the lack of current information on aggregate extraction activities in Solomon Islands, the consultants requested information from the Mines Division within the Ministry of Mines, Energy and Rural Electrification, on the building material permits (BMPs) to create a database of all active and regulated extraction sites (Figure 65). The approximate location of the s ites was extracted from the BMPs and Google Maps was then used to find their exact coordinates, with all operations in close proximity to Honiara (Figure 67). The analysis indicated that the number of building material permits issued annually increased significantly in 2022 compared to previous years. There are currently 27 extraction sites, operated by 14 operators including the Ministry of Communication and Aviation and Solomon Islands Port Authority. Of these extraction sites, 26 are river extraction operations and only one was a beach mining operation on Nughu Island. There are reportedly hard rock quarries, but information is not available on these, most likely because they are not operational.[308]

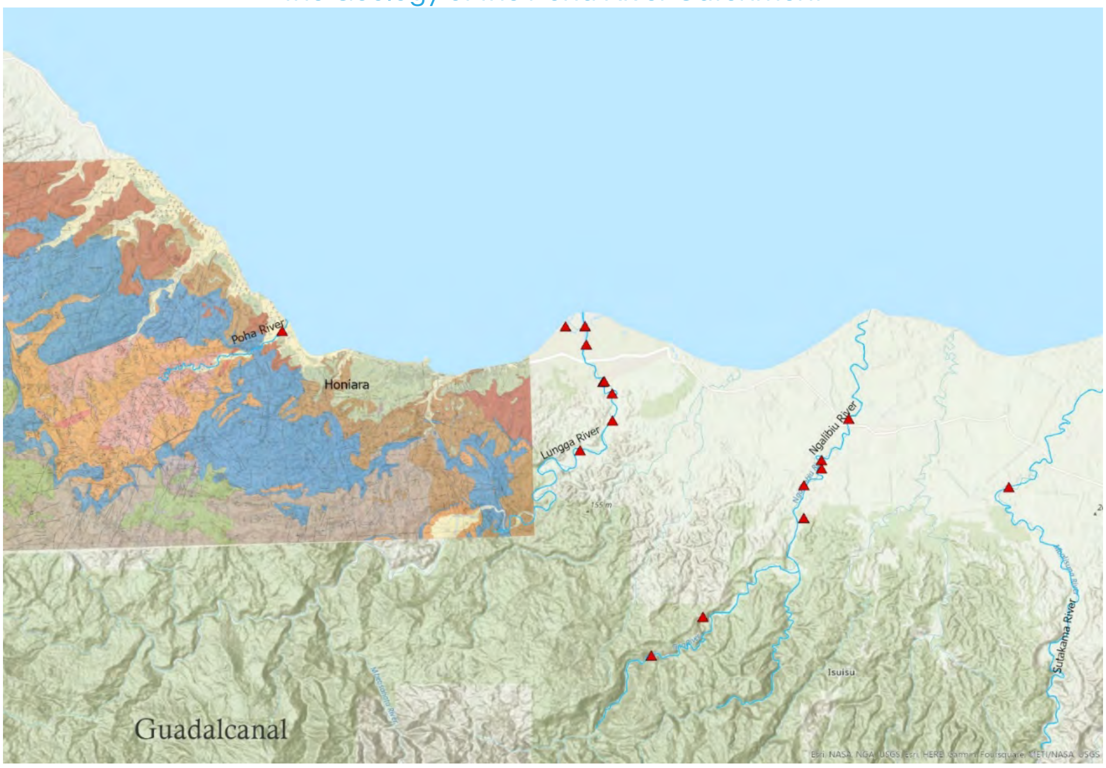
[308] Personal communication, donor representative. Dated 14/12/2024.

Figure 66: Number of Building Materials Permits Issued between 2016–2022 in Solomon Islands



Source: Solomon Islands Mines Division, Sept 2023

Figure 67: Location of Regulated River and Gravel Extraction sites in the Guadalcanal, and the Geology of the Poha River Catchment



Source: compiled by UQ

3.11.3 Aggregates required in the national infrastructure development plan

The Solomon Islands NIIP, published in November 2013 by the Ministry of Development Planning and Aid Coordination, outlined government priorities and major infrastructure projects planned over the 10-year period (2013 to 2023).[309] The plan outlined 19 priority projects across five sectors including transport, energy, urban development, water and waste management valued at $119.4 million (SI$1.02 billion). This plan has now technically expired; in 2021, the government reported that around 90% of the NIIP's "High Priority" projects had been advanced at that time.[310]

In 2021, the Solomon Islands Ministry of National Planning and Development Coordination, with the support of PRIF, also developed a priority infrastructure investment pipeline. It covers economic, social, and productive infrastructure sectors and is intended as an interim step to a full revision of the NIIP. The 27 highest-priority projects are estimated to cost SI$3.1 billion ($368 million) across nine industry sectors, though how many of these will actually go ahead is not known.

PRIF has also identified eight large infrastructure projects with a value of $264.5 million, with several of these likely to require large quantities of aggregate. As shown in Table 32, these cover four sectors including transport, energy, waste management and urban development.[311] It is likely that at least some of these projects align with projects identified under the priority infrastructure investment pipeline.

Table 32. Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members for Solomon Islands and Predicted Aggregate Demand

Sector	National Infrastructure Investment Plan Strategies	Project Name	Budget ($M)	Aggregate Demand	Assumptions
Transport	Support for uneconomic local shipping routes. Improving capacity of seaports to meet the demand of International Trade Traffic. Improve connectivity of wharves.	Land and Maritime Connectivity Investment Project - Tranche 2	53	High	Requires large volumes of concrete and cement.
Transport	Support for uneconomic local shipping routes. Improving capacity of seaports to meet the demand of International Trade Traffic. Improve connectivity of wharves.	Land and Maritime Connectivity Project, Tranche 3	52	High	Requires large volumes of concrete and cement.
Transport	Support for uneconomic local shipping routes. Improving capacity of seaports to meet the demand of International Trade Traffic. Improve connectivity of wharves.	Solomon Island Seascape Shipyard	4.1	Low-Medium	Requires low-medium volumes of concrete, cement depending on the size of the project.
Transport	Support for uneconomic local shipping routes. Improving capacity of seaports to meet the demand of International Trade Traffic. Improve connectivity of wharves.	Noro Port Upgrade	27.4	Medium-High	Likely requires large quantities of concrete.
Energy	Improve energy efficiency and costs. Convert to renewable energy sources.	Sustainable Solar Development	50	High	Requires large volumes of aggregates for the

[309] Pacific Regional Infrastructure Facility. (2013). Solomon Islands National Infrastructure Investment Plan 2013–2023. Summary paper. https://www.theprif.org/document/solomon-islands/national-infrastructure-investment-plans/solomon-islands-national-0. Accessed 11/09/2023.

[310] Solomon Islands Priority Infrastructure Investment Pipeline. Ministry of National Planning and Development Coordination, Government of Solomon Islands. https://www.theprif.org/sites/default/files/documents/SI%20Priority%20Pipeline%20Aug21_0.pdf Accessed 31/01/2024.

[311] Pacific Regional Infrastructure Facility. (2023). PRIF Infrastructure Pipeline Projects. Internal report.

Sector	National Infrastructure Investment Plan Strategies	Project Name	Budget ($M)	Aggregate Demand	Assumptions
		Investment Program			construction of hydro-dams.
Urban Development/ Waste management and Sanitation	Controlled and well managed waste sanitary landfills. Reduced uncontrolled informal waste disposal.	Honiara Sustainable Solid Waste Management Project	15.01	Low-Medium	Requires low-medium quantities of aggregates based on the size and type of facility.
Urban Development	Access to health facilities. Ensure quality health care.	Project for Construction of Kilu'ufi Hospital	20	Medium-High	Likely requires moderate to large volumes of concrete and cement.
Transport	Build and upgrade physical infrastructure and utilities to ensure that all Solomon Islanders have access to essential services and to markets.	Provincial Runways	43	High	Requires large volume of aggregates (gravel, stone) to build airport runways.
Total			**264.51**		

Source: PRIF, 2023

3.11.4 The legal and policy framework

Land and resource ownership

In Solomon Islands, land is classified into three categories: customary land, fixed term leases, and perpetual estates (equivalent to freehold). Approximately 85% of the land is under customary resource tenure,[312] while the remaining land is owned by the government and subject to registration under the Land and Titles Act (Amended) 2016.[313]

Land and Titles Act 1996

The Land and Titles Act is the primary legislation governing land tenure systems and administration in Solomon Islands.[314] The act defines all land categories and lays out the procedures for land acquisition, lease, and purchase. The Land and Titles Amendment Act 2016 revises this act to provide a right to resume certain fixed-term estates.

Government land can be purchased by individuals or companies through the process of granting, transferring, subleasing, or providing temporary occupation of government land. There are four types of private title ownerships:

1. Perpetual Estates Title, equivalent to freehold land.
2. Fixed Term Estate (FTE) Title. The Commissioner of Land can grant FTE Title to PE lands acquired by individuals or companies. FTE Titles can only be granted on 50–75 year terms.

[312] UNDP. (2021). *Enjoying Land Rights in Solomon Islands*. https://www.undp.org/pacific/news/ enjoying-land-rights-solomon-islands. Accessed 13/09/2024.

[313] Asian Development Bank. (2020). *Land Acquisition and Resettlement Framework, Solomon Islands: Land and Maritime Connectivity Project*. https://www.adb.org/sites/default/files/linked-documents/53421-001-rfab.pdf. Accessed 13/09/2023.

[314] Food and Agriculture Organization of the United Nations. Land and Titles Act (1996). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC050852/. Accessed 13/09/2023.

3. Sublease Title. The FTE title holder can lease the land to an individual or company for a period less than the FTE term allows.
4. Temporary Occupations Title. Occupation of land under license conditions for up to 3 years.

There are two ways the government can acquire land from its owners under the Land and Titles Act (amended 2016):

1. Customary Land Acquisition. Land ownership claims are made through reference to customs and traditions: Division 1 (Part V) of the Land and Titles Act, gives the Commissioner of Land the right to acquire customary land for public purposes.
2. Compulsory Acquisition: Division 2 (part V) of the act gives the Minister of Lands the power to acquire any customary land when it is required for public purposes without the consent of the owners. Under the country's Constitution, involuntary land acquisition is allowed only when:
   - it is necessary in interests of defense, public safety and order, public morality, public health, town or country planning, development or for any use that promotes the public benefit;
   - there is reasonable justification for causing any hardship to the interest holder;
   - it is done under a law that provides for reasonable compensation (including lump sum or instalments, and by cash or other form) in a reasonable time; and
   - it is done under a law that provides interest holders with the option of appealing to the High Court with respect to their ownership, the legality of the acquisition, or the compensation payable.

Solomon Islands National Development Strategy 2016–2035

In 2016, the Ministry of Development Planning and Aid Coordination published the Solomon Islands' National Development Strategy (NDS), a development plan which identifies the government's main strategies, priorities, and targets to improve the social and economic livelihoods in the country over the following 20 years (2016–2035).[315] The NDS sets out eight main objectives to reach these targets (Table 33). Objective 5 refers specifically to the development of infrastructure and facilities.

Table 33. Summary of the Solomon Islands' National Development Plan and Their Association with Infrastructure Development and Aggregate Use

	Key Objectives and Strategies	Infrastructure required to meet targets
1.	To alleviate poverty and provide greater benefits and opportunities.	Construction of water supply projects, healthcare centers, schools, leisure centers, improving access to healthcare and education.
2.	To ensure that all Solomon Islanders have access to quality health care and to combat malaria, human immunodeficiency virus, non-communicable and other diseases.	Construction of water supply and Sanitation infrastructure in rural communities, and water supply and sewerage systems in urban centers. Construction of health centers and hospitals.
3.	To ensure that all Solomon Islanders have access to quality education and for the country to	Construction of schools, culture, and sports centers.

[315] Ministry of Development Planning and Aid Coordination, National Development Strategy 2016 to 2035: Improving the Social and Economic Livelihoods of all Solomon Islanders.

Key Objectives and Strategies	Infrastructure required to meet targets
adequately and sustainably meet its manpower needs.	
4. To increase the rate of economic growth and equitably distribute the benefits of employment and higher incomes amongst all the provinces and people of Solomon Islands.	Expansion of the tourism industry and increase in the economic investments in the country. Provide affordable and resilient infrastructure. Remove barriers to trade through greater road network connectivity, upgrading of airports and seaports.
5. To build and upgrade physical infrastructure and utilities to ensure that all Solomon Islanders have access to essential services and to markets.	Upgraded and new transport systems and network, wharfs, and jetties, upgrading airfields and developing a national information and communication technology system. Establishing clean energy sources.
6. To effectively manage and protect the environment and eco-systems and protect Solomon Islanders from natural disasters.	Improve resilience to climate change and its impacts through coastal protection infrastructure, resilient road and housing infrastructure and transition to renewable energy sources.
7. To improve governance and order at national, provincial and community levels and strengthen links between them	Construction of police stations, local council offices, public spaces. Increased economic relations with other Pacific Islands.

Source: National Development Strategy 2016 to 2035

Environment Act 1998

The Environment Act is the main legislation that governs the conservation and protection of natural resources.[316] [317] The act provides provisions for the establishment of the Environment and Conservation Department (ECD) and the Environment Advisory Committee.

The act also provides for an integrated system of development and pollution control measures, as well the mitigation of the environmental impacts associated with development activities such as extraction of aggregates.

According to Article 4 (1), in the event of conflict between the Environment Act and other acts, the provisions of the Environment Act supersede other acts.

Part III of the act indicates that, for all development activities, developers must apply for Development Consent and provide a relevant EIA report and any other required information. The Director of ECD then reviews the application and makes a decision whether or not to grant Development Consent.

Policies

Environment Regulation 2008

The Environment Regulation framework was developed to effectively administer the implementation of the Environment Act.[318] It entails detailed requirements for assessment of all development activities identified on the Prescribed Developments list within the Environmental Act. All prescribed developments are required to go through a simple evaluation process, to see what form of additional assessment is required. Most development projects require a Public Environmental Report (PER). Major projects will also need to go through a second stage of assessment which includes technical,

[316] Environment Act 1998. https://policy.asiapacificenergy.org/node/805. Accessed 11/09/2023.

[317] Environment and Conservation Department, Ministry of Environment, Conservation and Meteorology 2010, Environment Impact Assessment Guideline 2010.

[318] Food and Agriculture Organization of the United Nations. Environment Regulations 2008. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC137466/. Accessed 11/09/2023.

economic, environmental, and social investigations that are to be presented in an Environmental Impact Statement (EIS). Schedule 2 of the regulation provides guidelines to assist in preparing the EIS/PER.

Environment Impact Assessment Guideline 2010

The guideline is designed to administer Schedule 16 of the Environment Act. It comprises EIA procedures, stakeholders to be included in the process, and the application fees required. The guideline was prepared by the ECD in order to streamline EIA procedures, oversee implementation, and provide basic advice and guidance to government officers, planners, developers, and resource owners (Table 34).

Table 34. A Summary of the Environmental impact Assessment Process for Development Projects in Solomon Islands

Step	Description	Involved institutional and community stakeholders
1. Proposal Application	Lodge proposal application to the ECD. Act 17(1) & Reg 6	Developer
2. Screening	ECD screens the proposal application and decides if EIA is required. In the case EIA is not required, go to step 13. If EIA is required, then go step 3	ECD & Developer
3. Scoping	Developer carries out an EIA study to identify the impacts of the development. ECD will then advise the developer of the type of information required and will decide whether PER or EIS is required of the developer. Act 17(2) and Reg 7	ECD & Developer
4. EIA Study	Developer carries out studies to collect and prepares the PER (step 5) or EIS (step 9).	Developer
5. Submission of PER and Development Application	Developer prepares and submits PER and the development application form. Act 17(2a) & 30	Developer
6. 1st Review	ECD reviews the application to determine the nature of the proposal. If the PER meets the act requirements, the process moves to Step 7. Act 21, 29and Reg 8 (a)(b)(c)	ECD
7. PER Public Display	PER document is made available to the public and ECD will convene a meeting that ensures public participation. Act 22(1,2),30 and Reg 11& 12	ECD, relevant organization, provincial government, developer, resource owners/users, public.
8. 2nd Review	ECD reviews PER taking into consideration any objections and suggestions received during the public display meeting or after the meeting. ECD may then: 1. Approve (step 13) 2. Reject- developer may appeal to advisory committee (step 14) 3. Deferred for approval- ECD may require an EIS from developer (step 9) Act 22(3), Reg 8(e),13	ECD
9. Submission of EIS and Development Application	Developer prepares and lodges the EIS and development application. If the EIS meets the requirements of the act, the process moves to Step 10.	Developer

Step	Description	Involved institutional and community stakeholders
	Act 17(2b) and 30	
10. 1st EIS Review	ECD reviews the application. If the EIS does not fulfill the requirements of the act, ECD may advise the developer to submit further information. If the EIS meets the act requirements, the process moves to Step 11. Reg 8 (a)(c)	ECD
11. EIS Public Display and Participation	The ECD will publish the EIS document to the public and convene a meeting that ensures public participation. Act 24(1)(2),30 and Reg 11 & 12	ECD, Any person, relevant organization, provincial government, developer
12. 2nd EIS Review	The EIS is reviewed again by ECD taking into consideration any objections and suggestions received during the public display meeting or after the meeting. ECD may then: 1. Approve (step 13) 2. Reject- developer may appeal to advisory committee (step 14) Act 24(3), Reg 8e	ECD
13. Approval	The development consent is issued to the developer with conditions and the decision will be made available to the public. Act 24(3a) and Reg 14,16	ECD
14. Appeals 1 & 2	The developer or any person(s) who disagrees with any decision of the Director can appeal the decision to the Environment Advisory Committee in writing, clearly stating the grounds of appeal. Act 32(1)(2)(3)(4)(5)(7) and Reg 18	ECD/ Any person
15. Monitoring	ECD or any relevant public authority monitors all environmental and health aspects of the development activity during the delivery and operational phase. Ref: Act 31	ECD/ Relevant public agency

ECD = Environment and Conservation Department, EIS = environmental impact statement, PER = Public Environmental Report.

Source: Environmental Assessment Guidelines 2010

Climate Change Policy

The Climate Change Policy describes the steps the government should take for the country to adapt to present and future impacts of climate change.[319] The policy aims to integrate climate considerations within the framework of national policies and guide the government and stakeholders to take steps to ensure that people, the natural environment, and economy are resilient and able to adapt to the predicted impacts of climate change. The Ministry of Infrastructure Development (MID) has developed a climate change manual to guide developers on climate change impact assessment and mitigation. Development projects must take into consideration the risks of climate change

[319] Solomon Islands' National Climate Change Policy 2012. https://www.adaptation-undp.org/resources/naps-least-developed-countries-ldcs/solomon-islands%E2%80%99-national-climate-change-policy-2012. Accessed 11/09/2023.

(extreme weather events, flooding, erosion, emissions etc.) to ensure potential risks have been considered in the design and operation of development activities.

Mines and Minerals Act 1996 (Amended 2014)

Under the act (Section 64), every developer who aims or plans to mine building materials (clay, gravel, sands and stone) must apply for a BMP and prepare a gravel extraction plan. Section 65 outlines the format of the BMP application which must then be submitted to the Director of Mines along with a receipt of payment of a prescribed fee, which is typically paid at the Inland Revenue Division. Section 66 outlines the forms and content of the BMP application, and Sections 67 and 68 provide for the rights and obligations of the BMP holder. Meanwhile Section 69 provides for exemptions for government to mine building materials on any government owned land.[320]

Mines and Minerals Regulations 1996

The Mines and Minerals Regulations outline the steps and guidelines to sustainable mineral sourcing and management in the country.[321] The regulations indicate that mineral rights holders, including building materials permit holders, must comply with the regulations to minimize the adverse ecological and social impacts of their activities.

The MID Safeguards Procedures Manual

The Safeguards Procedures Manual has been prepared by the Ministry of Infrastructure Development to manage environmental and social impacts and risks that could arise while implementing the Solomon Islands National Transport Plan.[322] The manual also includes guidelines for responsible sourcing of road construction materials including river gravel and coral deposits.

3.11.5 The institutional and operating framework

Ministry of Environment, Climate Change, Disaster Management and Meteorology

This is the institution responsible for sustainable environmental management in Solomon Islands. The ECD is the agency within the ministry that reviews PERs and EISs, and issues Development Consent for development projects. The ministry is also responsible for inspecting developments during the project delivery and the operational phase to ensure compliance with the conditions outlined in the Development Consent.

Ministry of Infrastructure Development

MID is responsible for delivering safe, reliable, integrated, and sustainable infrastructure and transport systems that comply with the government's development strategies. The Ministry manages the development of public roads, bridges, airstrips, wharves, and other public structures. The Central Project Implementation Unit is the implementing agency within MID responsible for implementing

[320] Food and Agriculture Organization of the United Nations. Mines and Minerals Act 1996. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC136359/. Accessed 11/09/2023.

[321] Food and Agriculture Organization of the United Nations. Mines and Minerals Regulation 1996. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC137489/. Accessed 11/09/2023.

[322] Ministry of Infrastructure Development, Solomon Islands Government. (n.d.). *Safeguards Procedure Manual*. https://www.adb.org/sites/default/files/linked-documents/46499-002-spmab.pdf. Accessed 11/09/2023.

safeguard requirements during the delivery and operational phase of infrastructure development projects.

Ministry of Mines, Energy and Rural Electrification

The Mines Division is one of the divisions that make up the Ministry of Mines, Energy, and Rural Electrification. It is responsible for executing and administering the Mines and Minerals Act.[323] There are three other sections, apart from the Directorate Office in the Mines Division that carry out these responsibilities and obligations. The roles and responsibilities of these sections are summarized in Table 35.

Table 35. A Summary of the Mine Division's Operating Sections and their Responsibilities, Solomon Islands

Section	Description
Economic Geology Section	• Policy formulation for the country's mining and minerals sector.
Tenement Section	• Managing all exploration tenements, administration and facilitating of minerals rights and updating tenement maps. • Facilitating the applications for the mineral rights: 1. Reconnaissance Permit (Required for exploration for identifying existence of m mineral potential) 2. Mining Lease (required prior to engaging in any mining activity) 3. Building Material Permit (required for the mining of building materials such as sand, gravel, and stone). 4. Alluvial Miners License (required if alluvial minerals are planned to be mined. Assumption is this is only required for gold and other precious minerals) • Coordinates and liaises with the Directorate office and the landowners and companies in facilitating negotiations for land access agreement before the lease is signed. • Ensuring the process under the Mines and Minerals Act is followed by all parties involved.
Inspection and Monitoring Section	• Inspecting and monitoring all prospecting and mining activities by ensuring all facilities have approved mining plans, production schedules and environmental management plans.

Source: Ministry of Mines, Energy & Rural Electrification

3.12 Tonga

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Tonga	**Medium** The National Infrastructure Investment Plan (NIIP) identifies ~$232.75 million in priority projects to be implemented between 2021 and 2030.	- Limestone - Beach sand (not sustainable)	**Low-medium** 2020–2022 imports: 124.6 tons 2020–2022 exports: 0 tons Tonga has only limestone resources of varying quality to supply the

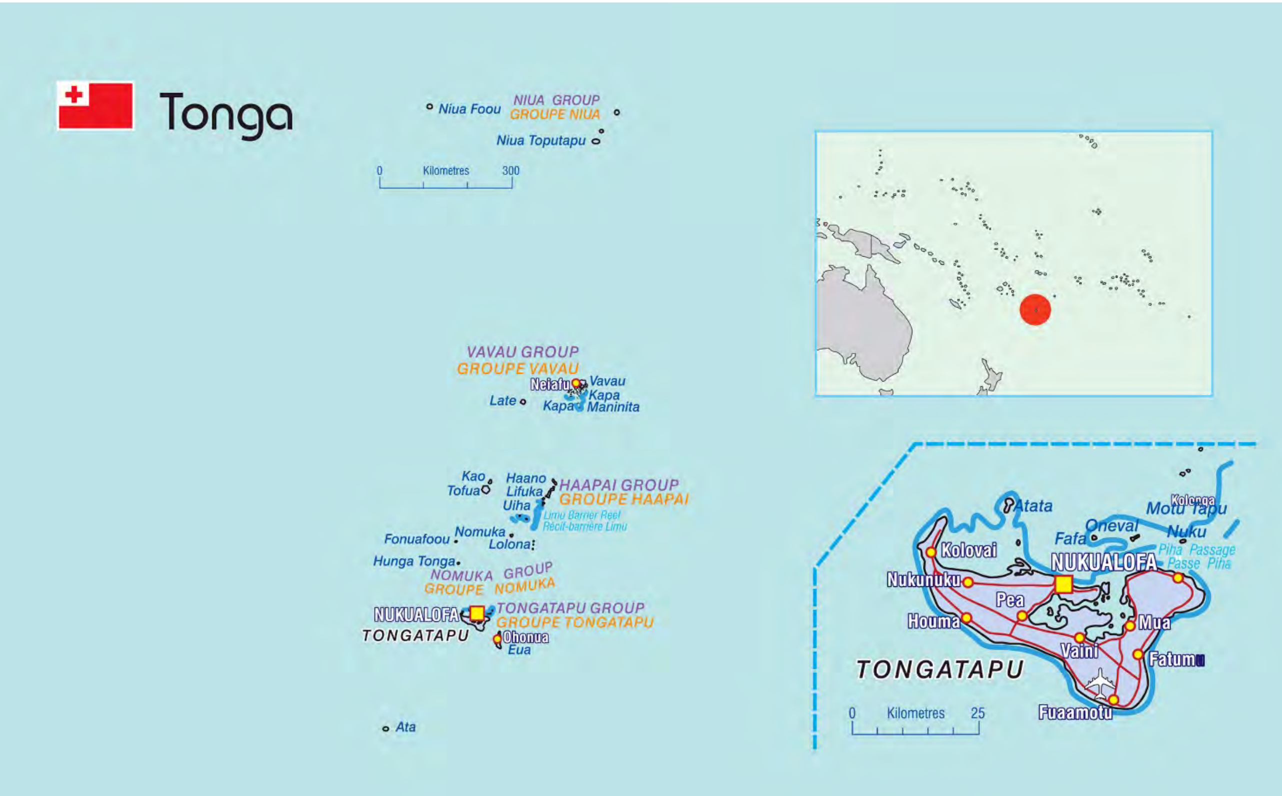
[323] Ministry of Mines, Energy & Rural Electrification, Solomon Islands Government. https://www.mmere.gov.sb/index.php/alias-about-us/technical-divisions/mines.html. Accessed 11/09/2023.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	$197.1 million in projects have been identified by PRIF.		infrastructure construction projects in the coming years. There will likely be a continued need to import better quality materials and sand to supply the infrastructure sector in the coming years, particularly sand, though only a modest 124 tons of aggregate was imported between 2020–2022. Nevertheless, the relatively large pipeline will likely increase aggregate demand beyond what Tonga can produce itself.

3.12.1 Geography and geology

The Kingdom of Tonga is an archipelago consisting of 170 islands, of which only 36 are inhabited by a population totaling 106,000. Tonga consists of three main island groups: Tongatapu in the south, Ha'apai in the center and Vav'au in the north. A number of its islands are isolated, including Niuafo'ou, Niuatoputapu, and Tafahi in the far north and 'Ata in the far south. Tonga's total land area (717 km^2) is dispersed between latitudes 15° and 23° South and longitudes 173° and 177° West. The capital Nuku'alofa is located on the main island of Tongatapu (Figure 68).[324]

Figure 68: Location Map of Tonga



Source: Mapsland

[324] *Encyclopedia Britannica*. https://www.britannica.com/place/Tonga. Accessed 11/09/2023.

Tonga is located on the crest of the Tonga Ridge, west of the Tonga Trench at the Pacific Plate boundary. The eastern islands are comprised mainly of limestone whereas islands of the western chain are volcanic. The eastern islands, which are Tongatapu, ‘Eua, and most of the islands of the Vava'u and Ha'apai groups, are composed of Quaternary limestones that are up to 250 m thick and overlie Tertiary volcaniclastic rocks. There are few minor igneous rocks exposures on 'Eua.[325]

Tongatapu is comprised of Pliocene and Pleistocene limestone on top of lower Pliocene and older volcaniclastics. It is surrounded by coral reefs and covered with thick fertile soil consisting of volcanic ash from emergent and submarine volcanoes.[326]

The Vava'u Group is comprised of two main limestone units. The upper unit of Quaternary coralline limestones rests on bedded limestones which are thought to be of Pliocene age. These older limestones are exposed in the lowest parts of Tefisi where they are described as well bedded, soft, fine grained, detrital tuffaceous limestones with tuff interbeds. The coralline limestones developed on the Pliocene base as a series of reefs of hard, dense, coral/algal bound limestone with flanking beds of detrital, loosely cemented reef rubble.[327]

3.12.2 Summary aggregate extraction sites and known resources

Beach mining has been the major source of fine aggregates required for the building and construction industry in Tonga. Some of the areas previously and currently mined include western, south-eastern, and eastern Tongatapu. Beach mining has been associated with significant environmental, political, and social concerns and efforts have been made to convert to lagoon dredging for sand resources in recent years.[328] Beach sand mining has been banned since 2002 but illegal extraction continues in some places.

Limestone is widely quarried on Tongatapu and Vava'u and to a minor degree on Eua and Ha'apai islands. Most of the limestone quarried in Tonga is used for building and road construction purposes such as pavement surface layers (aggregate for asphalt), pavement base material (crushed coral), concrete, and revetments and wave barriers. Cement is imported but concrete is locally produced in existing batching plants using local aggregates (Royco Ready Mix Plant).[329]

A list of ten known quarries which were potential sources of aggregates was reported in Tongatapu for the 2020 Nuku’alofa Port Upgrade Project Final report.[330] Another, four quarry sites were

[325] Harrison, D.J. (1993). The Limestone Resources of Tongatapu and Vava’U, Kingdom of Tonga. *British Geological Survey Technical Report* WC/93/23, Overseas Geology Series.

[326] Ibid.

[327] Ibid.

[328] SOPAC (1996). *SOPAC Projects*, A Publication Summarizing SOPAC Technical Work, Sand and Gravel Mining. Tongatapu, Tonga: Number 8.

[329] Harrison, D.J. (1993). The Limestone Resources of Tongatapu and Vava’U, Kingdom of Tonga. *British Geological Survey Technical Report* WC/93/23, Overseas Geology Series; Asian Development Bank (2020). *Tonga: Nuku’alofa Port Upgrade Project, Strategic Procurement Planning and Procurement Risk Assessment*. https://www.adb.org/sites/default/files/linked-documents/53045-003-sd-04.pdf. Accessed 11/09/2023.

[330] Harrison, D.J. (1993). The Limestone Resources of Tongatapu and Vava’U, Kingdom of Tonga. *British Geological Survey Technical Report* WC/93/23, Overseas Geology Series; Asian Development Bank (2020). *Tonga: Nuku’alofa Port Upgrade Project, Initial Environmental Examination*. https://www.adb.org/projects/documents/ton-53045-003-iee-0. Accessed 11/09/2023; Asian Development Bank (2021). *Tonga: 6 Megawatt Hihifo Solar Power Project, Initial Environmental Examination*. https://www.adb.org/projects/documents/ton-53258-001-iee-0. Accessed 11/09/2023.

reported on Vava'u Island for the Lepepau'u Airport upgrade, of which only two were active as of 2013.[331] A summary is provided in Table 36 below.

Table 36. A Summary of the Known Aggregate Resources and Active Quarries in Tonga

Resource	Location	Activity status and description
	Limestone Quarries	
'Ahononou Quarry	Fua'amotu, Tongatapu	Active, 300 m^3/day
Royco Quarry	Tokomololo, Tongatapu	Active, 50 m^3/day
Pili Quarry / Nishi Quarry	Pili, Tongatapu	Active
Lida Quarry	Pelehake, Tongatapu	Active
Ca'Bella Pacific	Tongatapu, Tongatapu	Active
Nishi Quarry	'Utulau, Tongatapu	Active, 150m^3/day
Cabella Quarry	Tokomololo, Tongatapu	Active
Kelesi Quarry	Pelehake, Tongatapu	Active
Malopo Quarry	Pelehake, Tongatapu	Active, 100m^3/day
First Choice Quarry	Pelehake, Tongatapu	Active
Petani Quarry	'Eua Island	Active
Holonga Quarry	Vava'u Island	Unknown
Neiafu Quarry	Vava'u Island	Inactive
Quarry in the outskirts of Neiafu village	Vava'u Island	Active as of 2013
Otumohemohe Enterprises	Vava'u Island	Active as of 2013
	Offshore Sand Deposits	
Koloa Island	Between Northern Vava'u and Koala Island.	Established dredging operation in 1996. Current Status unknown. Estimated 306,000 m^3 of sand deposit.[332]
Northern Tongatapu, Tonga, between Fafa Island and the mainland	Area 1 – between west of Fafa Island and the mainland, Tongatapu. Area 2 - the reef platform and its northern margin in an area between Motu Tapu - Fukave and Ata Islands.	Minimum estimates of 4,000,000 m^3 and 3,000,000 m^3, respectively.[333]

[331] World Bank (2022). Tonga - Pacific Aviation Investment Project: Environmental Assessment (Vol. 3). Environmental management plan for Lupepau'u Airport (VAV) (English). Washington, DC: World Bank. http://documents.worldbank.org/curated/en/309911468308672107/Environmental-management-plan-for-Lupepauu-Airport-VAV. Accessed 11/09/2023.

[332] Min, G.H & Lee, S.R. (1999). Survey Report of Sand and Aggregate Resources at Vava'u, Kingdom of Tonga. *SOPAC Technical Report* 277.

[333] Richmond, B.M. & Roy, P.S. (1986). Nearshore Sediment Distribution and Sand and Gravel Deposits in Lagoonal Areas, Northern Tongatapu, Tonga. *CCOP/SOPAC Technical Report* 63.

Resource	Location	Activity status and description
Vava'u Lagoon	Eastern part of the lagoon is a broad back-reef shelf with varying water depths, some of which cannot be accessed for dredging.	Estimated sand resource volume of 2.25 million m^3.[334]
Eastern Faloa Island	Results indicated a resource with considerable variation in thickness in water depths ranging from 1 to 10 meters.	Unknown[335]

Sources: Harrison, D. J. (1993), ADB (2020, 2021, 2023), Min & Lee (1999), Smith & Kitekei'aho (1996), Smith, Kitekei'aho & Young (1996), Richmond and Roy (1986).

3.12.3 Aggregates required for the national infrastructure development

National Infrastructure Investment Plan 3

The NIIP 2021–2030 (NIIP) outlines the government's plans and priorities for the energy, telecommunications, water, solid waste management, and transport sectors, among others.[336] The plan prioritizes 26 projects with funding estimated at approximately T$550 million (~$236.84 million) based on the urgency and their social and economic benefits.[337] PRIF has identified five potential projects for support in the coming years.[338]

Table 37. Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members and Predicted Aggregate Demand

Sector	National Infrastructure Investment Plan targets and objectives	Project Name	Budget ($M)	Aggregate Demand	Assumptions
Transport	Maritime Sector, increasing the safety and resilience of all maritime activities, especially in relation to inter-island shipping. This will require investments in infrastructure and complementary initiatives to improve capabilities, facilities, and systems.	Nuku'alofa Port Upgrade Project	50.5	High	Requires large volumes of concrete and road base.
Transport	Roads Sector, new road to increase social and business connectivity and accessibility to markets.	Fanga'uta Lagoon Bridge Project	60	High	Requires large volumes of concrete, cement and road base.
Transport	Roads Sector, new road to increase social and business connectivity and accessibility to markets.	Tonga Nuku'alofa Lagoon Bridge	20.5	Low-Medium	Requires small-medium volumes of concrete, cement depending

[334] Smith, R., & Kitekei'aho, F. (1996). Lagoonal Sand and Gravel Resources Vava'u, Kingdom of Tonga. *SOPAC Technical Report* 237.

[335] Smith, R., Kitekei'aho, F., & Young, S. (1996). Lagoon Sand and Gravel Resource Investigations, Vava'u, Tonga. *SOPAC Preliminary Report* 85.

[336] Pacific Regional Infrastructure Facility (2021). Tonga National Infrastructure Investment Plan 2021–2023. https://www.theprif.org/document/tonga/national-infrastructure-investment-plans/tonga-national-infrastructure-investment-0. Accessed 11/09/2023.

[337] Based on a conversion rate of T$1 = $0.44 as of 31/12/2024.

[338] Pacific Regional Infrastructure Facility (2023). PRIF Infrastructure Pipeline Projects. Internal report.

Sector	National Infrastructure Investment Plan targets and objectives	Project Name	Budget ($M)	Aggregate Demand	Assumptions
					on the size of the project.
Transport	Aviation Sector, provide improved transport infrastructure construction, management and maintenance	Fua'amotu Airport Terminals	25	Medium	Requires medium volumes of aggregates.
Energy	Energy Sector, meeting the government's renewable energy targets and objectives.	Tonga Renewable Energy	41.1	Medium	Medium volumes of aggregates required for the construction of wind farms, though specific quantities will depend on project details.
Total			**197.1**		

Source: Tonga National Infrastructure Investment Plan 3 2021-2030; PRIF, 2023

3.12.5 Overview of the legal and policy framework

Land ownership

According to Tonga's Constitution (Part 111, s104), all land belongs, in principle, to the Crown and is classified as King's Land, Hereditary Estates of Members of the Royal Family, Hereditary Estates of Nobles, and government land (the Crown), as Crown Estates.[339] Hereditary Estates and government land are subdivided into allotments for every Tongan male over the age of 16. In theory, every male Tongan is entitled to a "tax allotment" of 3.3 hectares for agriculture, and a "town allotment" for residential purposes. In reality, there is now little land available for distribution, particularly in the Nuku'alofa area.

Minerals Act 1949 (Revised 2020 Edition)

The Minerals Act states that all minerals are property of the Crown (Section 3).[340] However, the act specifically excludes "clay, coral, lime, sand, or other stone or such other common mineral substances" from its definition of minerals (Sect. 2).

Other key provisions of the act include:

- For all minerals that are found on land other than Crown Land, the Minister of Lands has authority to determine appropriate royalties and compensation to landowners (Section 7).
- The Minister of Lands, with the consent of the Cabinet, can lease any land without consent of its owners for any period without exceeding the term of the mining lease. The lessee must pay "surface rent" to the Minister of Lands and through him to the owners of the land (Section 9).
- According to Section 12, royalties need to be paid to the Crown through the office of the Minister of Lands by all holders of exploration licenses, prospecting licenses, and mining leases in respect to all minerals won and worked by them, as follows:

  (a) for gold, 5% of the value;

[339] Constitution of Tonga Revised 2020 Edition. https://www.lands.gov.to/resources/legal-and-policy-framework. Accessed 11/09/2023.

[340] Government of Tonga. Minerals Act 1949. https://www.lands.gov.to/resources/legal-and-policy-framework. Accessed 11/09/2023.

(b) for silver, 1% of the value; and

(c) for other minerals, subject to regulations.

Seabed Minerals Act 2014

This act provides guidelines to regulate and manage exploration and mining activities of Tonga's seabed minerals under the jurisdiction of Tonga and related matters. However, sand and gravel is not including in the minerals covered in this act.[341]

Land Act 1927 (revised 2020)

Under section 22 of the act, the King, with the endorsement of the Privy Council, can make regulations "relating to the removal of sand, stone, metal, and materials on and from any Crown land or any other holding."[342]

Easements

According to Section 19 (11), the Minister of Lands has the power to compel any land holder to grant an easement to the Crown and has the broad power to approve all easements whether they involve the Crown or not.

Resumption of land

According to Section 138 of the act, the Minister of Lands with the consent of Cabinet, can reserve any land required for roads, public ways, commons, cemeteries, school sites, playgrounds, public health purposes for use by government departments or for other public purposes.

Section 141 states that the King, with the consent of Cabinet, can require any land for public purposes. In these cases, the Minister of Land must: (a) pay compensation for crops being grown on the land; (b) grant other land and pay compensation; and (c) pay compensation for existing buildings or buildings in the process of being constructed on the land to be resumed.

The King is responsible for making regulations specifying the rates of compensation for land resumed by the Crown, as well as for the crops and buildings found on the land and the methods for how these rates are calculated (Section 143,1).

National Spatial Planning and Management Act 2012

This act establishes the requirements for any development projects to obtain a Development Consent based on a Project Plan (Part IV s32).[343] Development Consent is required for development projects under the National Spatial Planning and Management Act 2012 (Part IV s32). The application must be accompanied by its EIA.

Dredgers are also required to have a business license through the Development License and Business Licenses Act 2002.

[341] Government of Tonga. Seabed Mineral Act 2014. https://www.lands.gov.to/resources/legal-and-policy-framework. Accessed 11/09/2023.

[342] Government of Tonga. Land Act Revised 2020 Edition. https://www.lands.gov.to/resources/legal-and-policy-framework. Accessed 11/09/2023.

[343] Government of Tonga. National Spatial Planning and Management Act Revised 2020 Edition. https://www.lands.gov.to/resources/legal-and-policy-framework. Accessed 11/09/2023.

EIA Act 2003

The EIA Act establishes procedures to assess potential environmental impacts associated with a project and to develop appropriate measures to manage them.[344]

Environment Management Act 2010

This act establishes the Ministry of Environment and Climate Change as the authority responsible for protecting and managing the environment and promoting sustainable development in accordance with the 2010 EIA regulations and 2003 EIA Act.[345] This Ministry is now known as the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC).

Environmental approval from MEIDECC

All proposals for development activities must be assessed by the Department of Environment (DOE) in order to be approved in accordance with the 2003 EIA Act and the 2010 EIA regulations.[346] Project proponents must first complete a Determination of Category of Assessment Form (Form 1 of Schedule 1 of the Regulations), which provides an overview of the proposed development and a summary of the existing and potential environmental impacts and mitigation measures. A registration fee also needs to be paid to the EIA Unit, within DOE. Based on this information, the Secretariat and the Minister determines whether the proposed development is a minor or major project.

If the development is considered a major project, MEIDECC will issue Form 3 (Major Projects) of the regulations and the proponent will need to submit an EIA report for review by the Secretariat. Based on this, the Secretariat makes recommendations to the Environmental Assessment Committee. The Minister then receives an assessment report and will either issue an approval (with or without conditions), a request further information, or a rejection. Recommendations are usually accompanied by an EMP. The EMP addresses environmental management and protection measures that are specific to the project under consideration.

If it is a minor project, the Minister will issue a Form 2. Approval will be granted with or without conditions and the project may proceed. The DOE, after completing assessment of the application and the process required by the EIA Act, makes a recommendation to the licensing authority about whether to issue the license. DOE may also attach conditions to the recommendations.

The Schedule of EIA Act 2003 lists the projects considered to be major projects. Of particular relevance to exploration and mining activities are: i) mining, being an activity that disturbs the surface of the land in excess of one hectare; ii) sand or gravel extraction from any beach within 50 meters of the high tide mark; and iii) cement works or concrete batching works in which more than 2,000 tons per annum are manufactured.

[344] Food and Agriculture Organization of the United Nations. Environmental Impact Assessment Act Revised 2020 Edition. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC049306. Accessed 11/09/2023.

[345] Government of Tonga. Environment Management Act Revised 2020 Edition. https://ago.gov.to/cms/basic-search.html. Accessed 11/09/2023.

[346] Food and Agriculture Organization of the United Nations. Environmental Impact Assessment Act Revised 2020 Edition. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC049306. Accessed 11/09/2023.

Policies

Land (Removal of Sand) Regulations 1936 (Revised 2020 Edition)

These regulations prohibit the taking or removal sand from the foreshore, other than the foreshore within the limits of any harbor, without a permit in writing by the Minister.

Land (Quarry) Regulations 1985 (Revised 2020 Edition)

These regulations prohibit quarrying activities and the removal of any stone from a tax allotment.

Environmental Impact Assessment Regulations 2010

These Regulations provide the criteria, procedures, and content of environmental impact assessments. They also define the factors to be considered by the Minister and the Secretariat of the Environmental Assessment Committee when considering likely environmental impacts of an activity. The regulations also stipulated that EIAs should be undertaken for all major projects.[347]

Tonga Strategic Development Framework 2015–2025

This sets out a high-level vision for the development of Tonga during 2015–2025. It outlines seven national outcomes and 29 organizational outcomes to support their achievement. Other than brief recognition of the potential adverse impacts of beach sand mining, there is no mention of the extraction of aggregates.[348] However, the document does discuss the mining industry, in particular seabed minerals (not including sand and gravel), and the use and management of natural resources and the environment, referring mostly to ecosystems, water, plant, and wildlife species.

3.12.4 The Institutional and operating framework

Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate change and Communications (MEIDECC)

MEIDECC is the institution responsible for the management of the environment and administering environmental-related legislation in Tonga. The Department of Environment (DOE) within MEIDECC is the agency responsible for monitoring and approving EIA reports in accordance with the EIA Act 2003 and the EIA Regulations 2010. DOE is also responsible for monitoring extraction activities to ensure compliance and sanctioning or penalizing operators that breach the conditions set forth in the Environmental Management Plan, developed through the EIA process.[349]

[347] Food and Agriculture Organization of the United Nations. Environmental Impact Assessment Regulations 2020. Available https://www.fao.org/faolex/results/details/en/c/LEX-FAOC110173. Accessed 11/09/2023.

[348] Food and Agriculture Organization of the United Nations. Tonga Strategic Development Framework (2015–2025). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC168846/. Accessed 11/09/2023.

[349] Asian Development Bank (2020). *Tonga: Nuku'alofa Port Upgrade Project, Initial Environmental Examination*. https://www.adb.org/projects/documents/ton-53045-003-iee-0. Accessed 11/09/2023

Ministry of Lands, Surveys and Natural Resources

The Ministry of Lands, Surveys, and Natural Resources administers all matters concerning the management and protection of land, natural resources, and energy of the Kingdom of Tonga in accordance with the national laws and regulations and obligations to global conventions.[350]

Ministry of Infrastructure

The Ministry's mission is to develop quality infrastructure policies and deliver sustainable, resilient, safe, and affordable infrastructure for the Kingdom of Tonga.[351] The Ministry is comprised of five divisions, namely: the Civil Aviation Division, Marine and Ports Division, Land and Transport Division, Building Control Division, and the Civil Engineering Division.

3.13 Tuvalu

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Tuvalu	**Medium** Compared to other countries in the region, Tuvalu has a modest infrastructure pipeline, with many of the projects identified under the 10-year Infrastructure Strategy and Investment Plan (2017-2026) likely to have already been completed, based on predicted timelines. PRIF has identified $70.6 million of future projects, with most requiring the importation of aggregates.	- Lagoon sand / gravel	**Low** 2020–2022 imports: 12,135.8 tons 2020–2022 exports: 0 tons Successful sand extraction operations for land reclamation (under TCAP) but there are no other types of aggregate locally available, which makes it highly reliant on imports of hard rock and gravel from countries like Fiji. Imports between 2020–2022 totaled more than 12,000 tons and, based on infrastructure development plans and other future coastal adaptation works, these levels of aggregate import will likely continue over the coming years.

3.13.1 Geography and geology

Formerly known as the Ellice Islands, Tuvalu is a group of nine islands centered in the central Pacific located between latitudes 12° and 6° degrees south and 175° east to 179 ° west. Five of these islands are coral atolls and four are reef islands. The islands are thought to have been settled by Polynesian people some 2,000 years ago.

[350] Government of Tonga, Ministry of Lands and Natural Resources. https://www.lands.gov.to/. Accessed 11/09/2023.

[351] Kingdom of Tonga, Corporate Plan & Budget Summary for FY2020/2021–2022/23. https://pmo.gov.to/wp-content/uploads/2020/11/MOI-CPBudget-Summary-2020.21-Final-Revised-English-31Jul2020-1.pdf. Accessed 03/02/2024.

Funafuti Atoll lies in the center of the island group (Figure 69). It is the main port of entry for sea and air, the location of the national government, the center of commerce and trade and industry, and is home to a significant portion of the population who live on the islet of Fongafale. This islet is 5 km long and up to 500 m wide with a total land area of only 1.45 km^2. Tuvalu's population is around 11,200, with about half living on Funafuti atoll.[352]

Figure 69: Map of Tuvalu

Source: worldometers.info

The Tuvalu Islands sit on top of the Pacific Plate and are thought to be formed by an old volcanic chain produced by a long-inactive hotspot. Given plate movement, it is probable that the parent volcanoes on which these atolls developed were formed just south of the equator in shallower water.[353] They then collected the vast thickness of carbonate deposits on sub-aerially eroded volcanic pedestals on their slow journey on the Pacific Plate, which is moving in a northerly direction. Unlike some linear volcanic island chains in the Pacific, the volcanoes that underlie the present-day Tuvalu

[352] Australian Department of Foreign Affairs and Trade (n.d.). *Tuvalu Country Brief*. https://www.dfat.gov.au/geo/tuvalu/tuvalu-country-brief. Accessed 20/11/2023.

[353] Scott, G. and Rotondo, G. (1983). A Model for the Development of Types of Atolls and Volcanic Islands on the Pacific Lithospheric Plate. The Smithsonian Institution. Washington D.C., USA.

are widely scattered and do not exhibit or conform to any apparent age linearity as seen, for example, with the Hawaiian Emperor chain.

3.13.2 Summary of aggregate extraction sites and known resources

Aggregate extraction Funafuti Atoll

The principal demand for aggregates is for reclamation material and only Funafuti Atoll has been extensively surveyed for lagoon aggregate resources. Most of this work has been concentrated along the lagoon side shoreline of Fongafale Island which, commencing in WWII, was the source of coral aggregates taken from borrow pits to build an airstrip that was essential for the Allied advance on Japanese-held Tarawa (Figure 70).

Figure 70: Completed Airfield on Fongafale, Funafuti Atoll 22 October 194

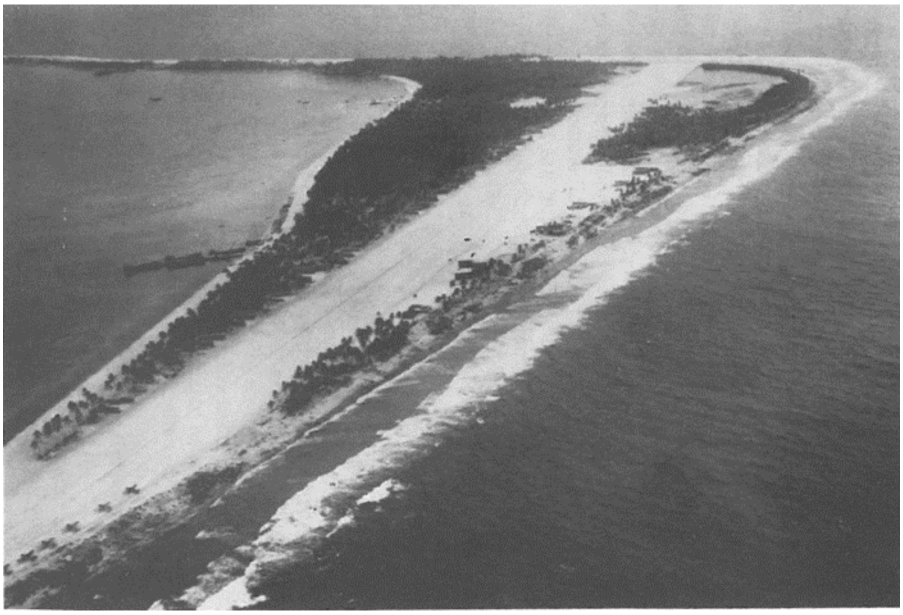


Photo credit: Bishop Museum Hawaii)

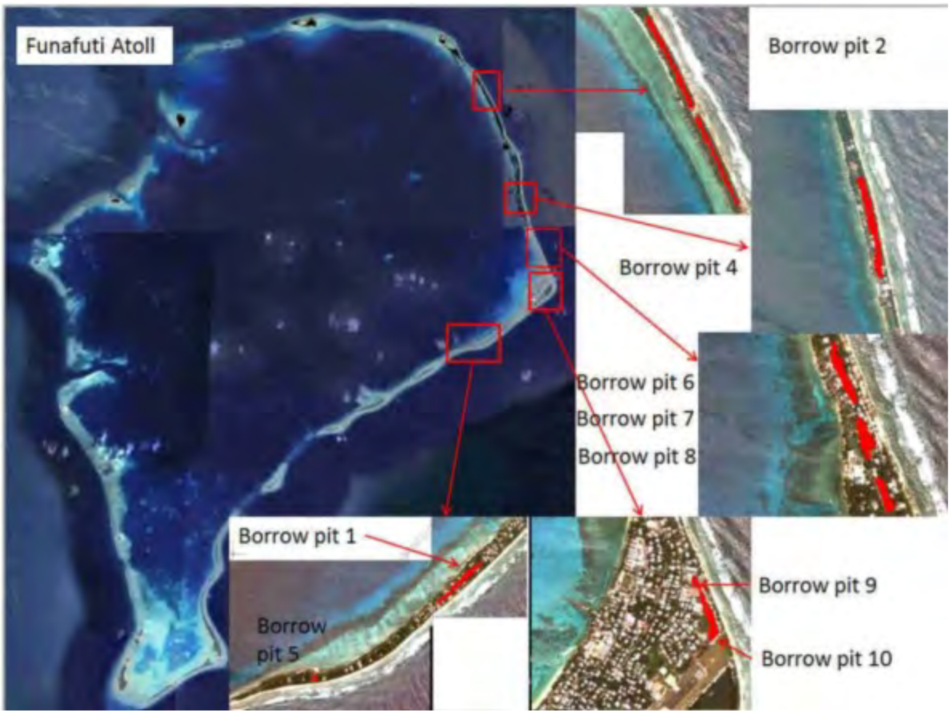
These borrow pits were a significant blight on the landscape of the island. The low-lying areas and the borrow pits accounted for 35% of the area of Fongafale Islet, restricting land availability.[354] The borrow pits themselves were effectively ponds, many of which had accumulated solid waste, presenting a significant health hazard. The largest of these was “borrow pit 2” at the northern end of Fongafale, which was being used for solid waste disposal (Figure 71). In total, there were 10 borrow pits (Figure 72).

[354] Smith, R. (2015). Sand Resources and UXO Survey – Funafuti Lagoon, Tuvalu. *SPC Geoscience Division Technical Report* PR 209.

Figure 71: Borrow Pit 2 at the Northern End of Fongafale Island. Top Picture Is from 2014 and the Bottom 2021

Photo: top ,Robert Smith; bottom, Hall Dredging

Figure 72: Location of the Ten Borrow Pits on Fongafale Island



Source: Smith 2014

The earliest studies to look at possible lagoon aggregate deposits for reclamation material date back to 1983 lagoon research undertaken by Gibb (Australia) Ltd., funded through the Australian Development Assistance Bureau. Further studies including a pilot project to test the suitability of lagoon aggregates for infilling borrow pits was undertaken by SOPAC between 1994–1995.[355] In 2003, the US Army Corps of Engineers was tasked by the US State department to provide a site analysis and cost study for filling the borrow pits on Funafuti, but it was not until 2012 that New Zealand's Ministry for Foreign Affairs and Trade decided to fund the reclamation of the borrow pits. Hall Contracting was contracted for the borrow infilling project, which commenced in 2014 through 2016. Some 300,000 m^3 of material was dredged to compete the infilling of the 10 borrow pits. By 2016, this had resulted in an increase in the available land area of Funafuti atoll by 8% at a cost of $7 million (NZ$10 million).[356]

In addition, a stockpile of approximately 30,000 m^3 was generated for government and local council construction activities, though this resource was rapidly depleted.

Figure 73: Funafuti Sand Stockpile North of Runway in May 2016

Photo credit: J. Kruger

The government of the day initiated further reclamation works adjacent to Vaiaku in central Fongafale beginning late 2015 through 2017 resulting in the creation of Queen Elizabeth Park. This was completed in time for the 50th Pacific Island Forum meeting in 2019. A UXO survey undertaken during the first survey was followed by a second in 2015 as part of the reclamation works.[357]

More recently reclamation has continued under the Tuvalu Coastal Adaptation Programme (TCAP) a joint Government of Tuvalu/United Nations Development Programme (UNDP)/Global Environment

[355] Eade, J. (1995). Summary Report of the Tuvalu Borrow Pity Infilling Pilot Project: 1989–1995. *SOPAC Miscellaneous Report* 190; Smith, R. (1995). Assessment of Lagoon Sand and Aggregate Resources, Funafuti Atoll, Tuvalu. *SOPAC Technical Report* 212.

[356] Radio New Zealand (2016). Tuvalu's Borrow Pits Finally Filled In. https://www.rnz.co.nz/international/pacific-news/299471/tuvalu's-borrow-pits-finally-filled-in. Accessed 20/11/2023; Values in New Zealand dollars converted using a 2016 yearly average exchange rate of NZ$1 = $0.70.

[357] Smith, R. (2015). Sand Resources and UXO Survey – Funafuti Lagoon, Tuvalu. *SPC Geoscience Division Technical Report* PR 209.

Facility initiative. Here, an area approximately 700x100 m has been reclaimed to an elevation of 6 m above sea level, requiring some 500,000 m^3 to generate an elevated land mass as part of a climate change adaptation mitigation strategy to strengthen coastal protection. The progressive reclamation of the lagoon shoreline of Fongafale is illustrated in Figure 74.

Figure 74: The Progressive Reclamation of the Lagoon Shoreline Adjacent to Vaiaku, Fongafale Island

Source: Google Imagery compiled by Robert Smith, 2023

On Nukufetau Atoll, the government also initiated a land reclamation and coastal protection project for Savave Island. Civil works were completed by Hall Contracting in 2016, though no specific resource surveys for lagoon aggregates were done for this project.

On Nukulaelae, the government has been building an airstrip to improve inter-island travel to the southern island. For this project, land and aggregate has been sourced directly onsite.[358]

[358] Personal communication, Tuvalu Minerals Officer. Dated 16/08/2023. These developments are most likely being funded under the Outer Island Maritime Infrastructure Project. See ADB (2024). Tuvalu: Outer Island Maritime Infrastructure Project, Environmental and Social Monitoring Report. Prepared by the Ministry of Public Works, Infrastructure, Environment, Labour, Meteorology and Disaster – Project Management Unit for the Government of Tuvalu and the Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-documents/48484/48484-002-esmr-en_8.pdf. Accessed 19/08/2024.

Figure 75: Nukulalelae Atoll. An Airstrip Is Visible in the Top Centre

Source: Google Earth imagery August 2023

Other known outer-island developments current and proposed include the following:

- Building of a wharf facility on Niutau using prefabricated concrete-form work products manufactured in Fiji[359]
- The construction of a 30x40 m community center
- Reclamation of elevated land as a mitigation measure for climate change protection on Nanumaga and Nanumea[360]

Offshore sand resources

In 2012, a company called Global Sands made estimates of the quantities of sand located in two regions within Tuvalu's EEZ, Martha Bank (10° 30' S, 179° 30' E) and Bayonnaise Bank (12° S, 179° 30' W). During recent communication, a representative of the company stated that there were vast potential sand resources at the locations:

> *Based on rough estimates the total sand reserves in those two areas are at a minimum 4.5 billion cubic meters, measured at 3 meters deep. Likely, the quantity of actual sand located within those areas exceeds all estimates, as the sand depth is in probability 10 meters or more. At 10 meters or more, the total sand reserves in Martha and Bayonnaise Bank may be estimated at a minimum of 15 billion cubic meters. A third sand reserve within Tuvalu's territorial waters promises enormous sand reserves at comparable levels. Total areas suggest that Tuvalu's sand reserves total upwards of 30 billion cubic meters.*

[359] Personal correspondence with the following stakeholders: CEO of infrastructure contractor; Tuvalu Minerals Officer. Dated 16/08/2023.

[360] See UNDP at https://www.undp.org/pacific/news/coastal-construction-designs-benefit-three-target-islands-tuvalu. Accessed 31/01/2023.

It is unknown if this area has been investigated to verify the existence of these sand resources. However, what is clear is that there are significant lagoon aggregates in various parts of Tuvalu with earlier studies estimating that there were around 24 million m^3 of sediments around Fongagale in Funafuti Lagoon alone.[361]

Beach mining

Beach mining does still occur in Tuvalu but at a very small scale. In the past mining of the Bebe gravel banks on the ocean side was common on Fongafale Island. These gravel deposits were formed during Cyclone Bebe in 1972 and were described in a study as an enormous ridge of coral rubble some 19km in length and up to 4m high that appeared dramatically overnight (Figure 76).[362] In 1992, Funafuti runway was tar-sealed to a capacity of 50 tons. Gravel accumulation on the southern end of Fongafale was extensive and was mined during the period the runaway was being upgraded.

Figure 76: Gravel Accumulation on the Southern End of Fongafale, 1995

Source: Xue, C. and Malologa, F. (1995). Coastal Sedimentation and Coastal Management of Fongafale, Funafuti Atoll Tuvalu. SOPAC Technical Report 221.

In 2008, the Foreshore Protection Act of 1969 was revised. This act deals with the ownership of the foreshore and regulating certain reclamation projects. In this act, no person is allowed to remove any sand gravel, reef mud, coral, or other like substance from the foreshore without first obtaining a license from the Kapule (Town Council), which has authority over foreshore areas.

Aggregate importation

A detailed discussion of aggregate supply chains and the environmental and social impacts of extraction in the region, including for Tuvalu, is provided in sections 4 and 5. But it is important to note here that sourcing construction aggregates in atoll nations like Tuvalu, Kiribati, and the RMI with limited geological resources presents numerous challenges related to the quality and

[361] Smith, R. (1995). Assessment of Lagoon Sand and Aggregate Resources, Funafuti Atoll, Tuvalu. *SOPAC Technical Report* 212.

[362] Maragos, J. E., Baines, G. B. K., and Beveridge, P. J. (1973). Tropical Cyclone Creates a New Land Formation on Funafuti Atoll. *Science*, 181:1161–1164.

quantity of local resources, social and environmental impacts of extraction activities, and elevated costs when aggregates are to be externally sourced.

Local councils have imported aggregate from Fiji for local construction projects and for sale. However due to the high cost these are slow sell. A 1 m^3 bag sells for A$300. Some barter for gravel does occur but at very small scale.[363] As discussed in section 4, both Tuvalu and Kiribati are highly dependent on imports of aggregates for large infrastructure projects. For instance, during 2020–2022, Tuvalu imported 19,171 tons of aggregate, all of which came from Fiji.

Figure 77: Imported Aggregates from Fiji that Have not Been Sold

Photo credit: Gary Lee, SPC 2023

3.13.3 Aggregates required for national infrastructure development

In 2017, Tuvalu released its Infrastructure Strategy and Investment Plan (TISIP).[364] Facilitated by PRIF, the TISIP is an update of an earlier TISIP released in 2011 and covers 2016–2025. It incorporates social and economic infrastructure and encompasses 14 sectors: Maritime Transportation, Air Transportation, Land Transportation, Water and Sanitation, Waste Management, Energy, Telecommunications, Coastal Protection, Education, Health, Multi-Sectoral (e.g., urban or Outer Island projects involving multiple sectors), and Other Government Buildings.

TISIP 2016–2025 supported Tuvalu's recently concluded National Strategy for Sustainable Development 2016–2020, Te kakeega III, the eighth national development plan. A total of 12 projects across nine sectors have been prioritized for the current TISIP, comprised of ongoing projects, those for which funding has already been committed, and those that have been nominated and are considered a high priority. The total projected budget of the plan was $158.5 million[365] for the 12 projects, with each in the range of $0.37 million and $31.2 million. Three projects are located in the capital, Funafuti, while the remainder involve one or more of the outer islands. Of the projects

[363] Personal communication, Tuvalu Minerals Officer. Dated 16/08/2023.

[364] Tuvalu Infrastructure Strategy and Investment Plan. https://policy.asiapacificenergy.org/node/3038#:~:text=The%20Tuvalu%20Infrastructure%20Strategy%20and,2016%E2 %88%922020%20(TKIII). Accessed 05/12/2023.

[365] Converted from Australian dollars at a 2016 average conversion rate of A$1 = $0.744.

prioritized for investment, the largest in terms of budget is the $16.4 million coastal protection infrastructure project for three islands (Funafuti, Nanumea, Nanumaga). It is understood that this project, which is already ongoing, is consuming a very large amount of aggregate in the form of armor rock, sand, and other rock.

Projects identified for potential funding by PRIF members, along with predicted aggregate demand, are shown in Table 38.

Table 38: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility Members and Predicted Aggregate Demand, 2023

Sector	Project Name	Budget ($M)	Potential Aggregate Demand	Assumptions
Transport	Tuvalu Safe and Resilient Aviation Project	18.0	High	Requires large volume of aggregates for concrete, asphalt, and pavement layers and roads, hangers, runways, taxiways, aprons etc. (dependent on design and specifications)
Transport	Tuvalu Nui Boat Harbor	14.6	High	Requires large amount of aggregates for concrete and boulders for breakwaters, and other facilities
Transport	Outer Island Maritime Infrastructure Project – Third Additional Financing (Nui)	25	Very high	As above but even greater demand given larger budget
Water and sanitation	Funafuti Water and Sanitation Project	4.0	Moderate	Requires moderate volumes of aggregates for concrete, and sand for water treatment. Likely to involve the construction of reservoirs, pumping stations, treatment plants, and pipelines among others.
Water and sanitation	Funafuti Water and Sanitation Project	9.0	Moderate to High	As above but slightly larger demand given budget size.
Total ($)		**70.6 million**		

Source: PRIF; relevant project reports where available

3.13.4 Overview of the legal and policy framework

Land and resource ownership

Native Land Act (Amended 2016)

This act provides for the registration, ownership, management, and transfer of native land.[366] The act also provides for the establishment of a Lands Code, land leases, land surveys and penalties in case of any land offence. Most of the land in Tuvalu is held in accordance with the Tuvalu traditional customs of the native population. The act also provides the process through which land can be

[366] Food and Agriculture Organization of the United Nations. Native Lands Act 2008 https://www.fao.org/faolex/results/details/en/c/LEX-FAOC099659/. Accessed 20/12/2023.

alienated, though it cannot be alienated to non-Tuvaluans by any means, either by sale, gift, lease, or otherwise.

Tuvalu Lands Code 1962 (Amended 2008)

This code, made under Section 28 of the Native Lands Act, governs native land rights in eight islands of Tuvalu: Nanumea, Funafuti, Nukufetau, Vaitupu, Nanumanga, Niutao, Nukulaelae, and Nui.[367] The code outlines the rules relative to land ownership rights and limitations, stating that the owner controls the use of his property. However, the Lands Code does not affect the validity of any mining licenses granted by the Crown conferring the right to carry out mining operations in Tuvalu.

Foreshore and Land Reclamation Act 1969 (Amended 2008)

This act states that the State owns the foreshore and seabed.[368] However, this is subject to public rights of navigation, fishing and passing over the foreshore as well as any private rights that may exist. The act also gives the Council of Elders (Kaupule) on each island the authority to issue licenses to people for certain activities, including the removal of sand, gravel, reef mud and corals. These activities are otherwise prohibited.

Climate Change Resilience Act 2019

This act provides for climate change responses and a sustainable transition to a climate-resilient and lower carbon economy and society.[369] The act provides the legal basis for climate change policy and law for all undertakings, either on land, water, or the airspace of Tuvalu. The main objectives of the act include the following:

1. to act as a basis for the provision of climate change resilience laws;
2. to give effect to a legal obligation of Tuvalu with respect to implementation and adherence to international climate change policies and agreements;
3. promotion of low carbon economy;
4. to guide on the establishment and implementation of the role of government in climate change issues; and
5. to promote the climate change agenda to the general public.

The government of Tuvalu is committed to both national and international climate change protocols to ensure the right mitigation of adverse effects resulting from global climate change challenges.

[367] Tuvalu Lands Code. https://leap.unep.org/en/countries/tv/national-legislation/tuvalu-lands-code-cap-46202. Accessed 20/12/2023.

[368] Food and Agriculture Organization of the United Nations. Foreshore and Land Reclamation Act. Accessed 20/12/2023. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC035673/

[369] Food and Agriculture Organization of the United Nations. Climate Change Resilience Act 2019. Accessed 20/12/2023. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC202478/

Environment Protection Act 2008 (Revised edition, CAP.30.25)

This act is an overarching legislative framework that provides for the management and protection of the environment and sustainable development.[370] It addresses issues pertaining to pollution, biodiversity and natural resources, environmental impacts, and waste management. The main objectives of the act include the following:

1. to play a central role in government regarding all issues of environmental protection and sustainable development through development of environmental policy and law;
2. to encourage the promotion and development of a healthy environment for all citizens;
3. to provide for the prevention, control, monitoring, and management of pollution;
4. to provide for the compliance and implementation of such environmental international laws to which Tuvalu is a member; and
5. to provide for better waste management practices and promote environmentally friendly disposal practices. This act provides for regulations dealing with pollution control, waste management, hazardous wastes and substances, and the procedures for environmental impact assessment, among others.

Environment Protection (Environmental Impact Assessment) Regulations 2014

This legal framework regulates the EIA process.[371] The regulations set out the assessment process, which includes a Preliminary Environmental Assessment Report (PEAR) to be prepared for all development projects and a full EIA to be prepared for activities that have significant environmental impacts.

Quarrying of aggregates is categorized as a development project (major project) under schedule 1, part 3 (d), which lists "commercial extraction of aggregates stones or shingles, sand, reef mud and beach rock". Hence, the establishment of any quarry is required by the Environment Protection Act 2008 to have an operational license.

Environment Protection (Environmental Impact Assessment) Regulations 2018

This regulation amends the Environment Protection (EIA) Regulation 2014.[372] Key changes include updates on the guidelines and the process of how the EIA of any development, including quarrying, must be carried out. The regulations also provide key updates on the screening of different categories of development projects. Three broad categories are classified as per Table 39 below.

[370] Food and Agriculture Organization of the United Nations. Environment Protection Act 2008. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC099601. Accessed 20/12/2023.

[371] Environmental Protection (Environmental Impact Assessment) Regulations 2014. https://ampeid.org/documents/tuvalu/environment-protection-(environmental-impact-assessment)-regulations-2014/. Accessed 20/12/2023.

[372] Food and Agriculture Organization of the United Nations. Environment Protection (Environmental Impact Assessment) Regulation 2018. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC220198.

Table 39: EIA Project Screening Category

Project Category	Description
Category A	This includes projects that might have significant social, economic, and environmental effects. Such effects might include adverse environmental impacts, community displacement/resettlement, and the production of hazardous materials.
Category B	This includes projects that are located in a certain geographical area and their effect can easily be controlled with minimal costs.
Category C	This category encompasses those projects and undertakings with negligible environmental impacts. Under Regulation 5 of the Environment Protection (Environmental Impact Assessment) Regulation 2014, this includes projects such as approved construction and maintenance of residences, and routine maintenance of public infrastructure.

Source: Environmental Impact Assessment Regulation 2018

In relation to the above project categories, the amended regulation also provides for the scoping of category A and B projects before an EIA is issued to ascertain such issues relating to the environment and society through consultation with the affected communities and to seek expert opinions on the key changes. The developers/proponents are now required to outline such issues as employment and labor opportunities, gender inequality, marginalized group inclusion, cultural and heritage site preservation, and public health and safety issues among others.

Also of importance are the changes to Regulation 12 that require all development projects irrespective of the ownership to have an approved EMP. This plan shall be implemented by the project proponents and monitored by the EIA officer. The plan must outline issues pertaining to the mitigation measures, reporting mechanisms, capacity building and training, and cost estimates, among others.

Mineral Development Licensing Act 2008

This act provides for the grant of licenses to search for and acquire mineral rights, with minerals defined broadly as "any substance, whether in solid, liquid or gaseous form, occurring naturally in or on the earth, or in or under the seabed formed by or subject to a geological process, but does not include water" (Part II section 3).[373] There are currently no known commercial mining operations in Tuvalu.

There is, however, potential for seabed mining, which is regulated by the Tuvalu Seabed Minerals Act 2014. Tuvalu is one of the PICs where deep-sea exploration has identified minerals such as gold, silver, copper, and nickel, among others.[374] The act does not address the extraction of minerals and materials such as sand, gravel, and rock used for building or construction purposes.

3.13.5 The Institutional and operating framework

Ministry of Communication and Transport

The Ministry of Communication and Transport is the government agency responsible for maintaining transport infrastructure including roads and maritime infrastructure.

[373] Food and Agriculture Organization of the United Nations. Mineral Development Licensing Act 2008. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC051730/. Accessed 30/12/2023.

[374] World Bank (2017). *Pacific Possible: Long-term Economic Opportunities and Challenges for Pacific Island Countries*. https://elibrary.worldbank.org/doi/epdf/10.1596/28135. Accessed 20/12/2023.

Department of Environment

The DOE sits within the Ministry of Home Affairs and Rural Development. Its responsibility includes the administration and enforcement of the Environment Protection Act. The DOE also reviews and assesses PEARs and EIAs and monitors the implementation of environmental safeguards for development projects. The ADB Outer Island Maritime Infrastructure Project Initial Environmental Examination reports that the DOE has limited staff capacity to provide compliance monitoring, especially in outer islands.[375] Hence, for big development projects, money must be allocated to hire a third-party consultant.

3.14 Vanuatu

Initial assessment of aggregate self-sufficiency

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
Vanuatu	**Medium to High** Current infrastructure development plan ends this year with new plan yet to be released. However, proposed projects will likely be as much, if not more, than the Vanuatu Infrastructure Strategic Investment Plan 2015–2024, which identified projects valued at $406 million. Projects identified by PRIF are valued at $171 million.	- limestone (coronus material) - basalt (mainly outer islands) - river gravel (outer islands) - beach sand (not sustainable)	**Low-medium** 2020–2022 imports: 27.9 tons 2020–2022 exports: 0 tons Good limestone deposits on Efate but limited basalt with no operational quarry. Outer islands have sand, river gravel, limestone and small (but potentially bigger) quantities of basalt resources though Vanuatu is still reliant on imports, with very large imports in recent years, though not all captured by trade data.

3.14.1 Geography and geology

Vanuatu, officially known as the Republic of Vanuatu, is an archipelagic country in Melanesia comprised of 83 islands and numerous small islets spread across the southwest Pacific. It spans around 1,300 km between latitude 12° and 23° S and longitude 166° and 173° E (Figure 78). Australia is located some 2,000 km to the west, while Solomon Islands (its closest neighbor) is 170 km to the north, New Caledonia 230 km to the southwest, and Fiji 800 km to the east.[376] Vanuatu's total land area is 12,336 km^2 but if its EEZ (200 km from the coastline) is factored in, the country's total area is around 860,000 km^2.

Only 12 islands have any significant population or economy with the largest being Espiritu Santo, Malekula, Erromango, and Efate, home to the nation's capital Port Vila and the country's largest

[375] Ministry of Communication and Transport and Asian Development Bank (2016). *Tuvalu: Outer Island Maritime Infrastructure Project – Initial Environmental Examination*. https://www.adb.org/sites/default/files/project-documents//48484-002-iee-01.pdf. Accessed 20/12/2023.

[376] UNEP (2005). State of Environment Report – Vanuatu. https://www.unep.org/resources/report/state-environment-report-vanuatu. Accessed 30/08/2023

population center with just over 60,000 people. As of 2023, Vanuatu's total population was 326,740.[377]

Vanuatu's climate varies from wet tropical in the north islands to drier subtropical in the south of the archipelago.[378] Average temperatures range between 21° C and 27° C and average humidity between 75% and 80%. The country is prone to cyclones during the warmer and wetter months between November to April, with Cyclone Pam in 2015 being one of the most destructive and intense cyclones to ever hit the southwest Pacific.[379] In fact, the United Nations World Risk Report of 2014 ranked Vanuatu as the most vulnerable country to disasters due to natural hazards globally.[380]

Part of the Pacific Ring of Fire, Vanuatu is an island arc resulting from geological activity at the New Hebrides subduction zone where the Australian Plate is subducting beneath the Pacific Plate. The islands of the archipelago began to emerge around 20 million years ago during the Miocene Period, but Vanuatu is geologically young, with most islands emerging from volcanic activity since the late Pleistocene, around 200,000 years ago. Both seismic and volcanic activity continue to this day with frequent earthquakes and active volcanoes on the Banks Islands and the islands of Ambae, Tongoa, Aneityum, and Tanna, as well as submarine volcanoes.[381] Tuffs resulting from explosive volcanic activity are the most common type of volcanic rock and are found in the form of agglomerates, pillows of lava and subaerial flows of basaltic nature.

[377] World Bank Open Data. https://data.worldbank.org/country/fiji?view=chart. Accessed 30/08/2023.

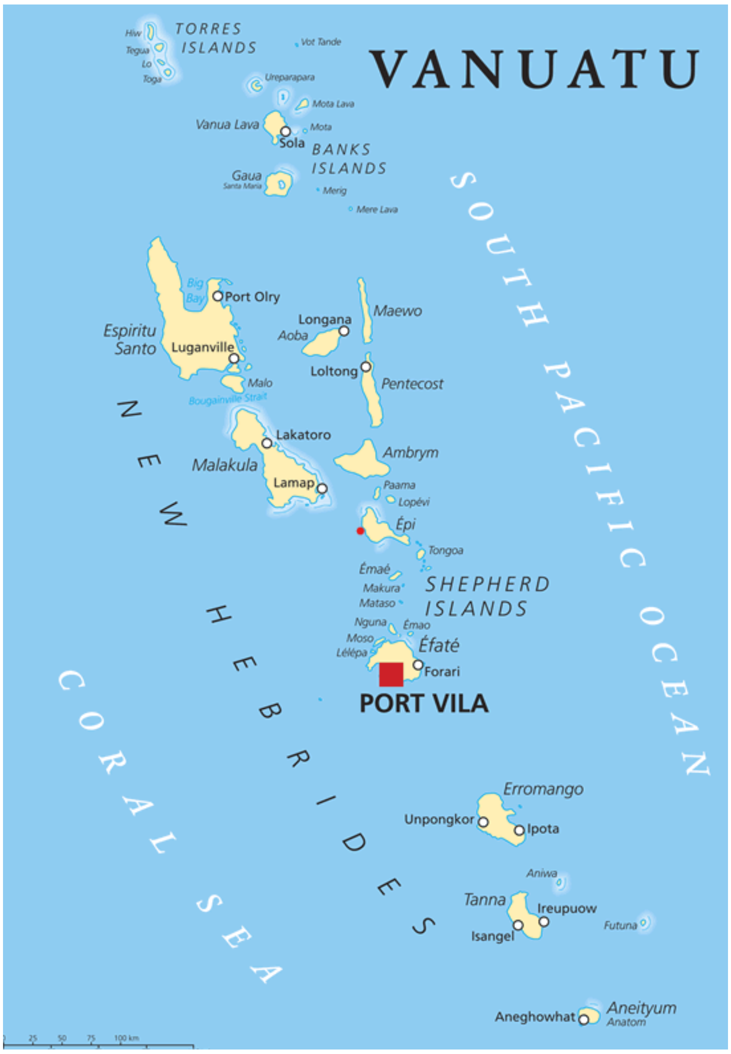
[378] UNEP (2005). *State of the Environment Report – Vanuatu*. https://www.unep.org/resources/report/state-environment-report-vanuatu Accessed 30/08/2023.

[379] Handmer, J. and Iveson, H. (2017). Cyclone Pam in Vanuatu: Learning from the Low Death Toll. *Australian Journal of Emergency Management*. 32(2).

[380] United Nations University (2014). *World Risk Report 2014*. https://i.unu.edu/media/ehs.unu.edu/news/4070/11895.pdf. Accessed 01/09/2023.

[381] Ministry of Transport, Public Works, Communications and Tourism (1989). National Transport Development Plan Final Report.

Figure 78: Map of Vanuatu



Source: geology.com

While many of Vanuatu's islands are mountainous and volcanic, there are also uplifted reef islands and various low-lying coral islands and reefs.[382] Some islands are partly or wholly comprised of limestone, such as Malekula. The islands with raised limestone, including Efate, benefit from a ready supply of coronus material that makes for good road surfacing, especially given the low volume on the island's roads. The more recently formed islands, including Tanna, do not have large coral deposits but do have very hard fine grain basaltic rock, which requires crushing for any use.

While streams and rivers are abundant, Vanuatu has relatively few long, permanent rivers. The largest are in Espiritu Santo and Malekula.[383] Most are characterized by steep gradients and large and rapid fluctuations of water flow, particularly during periods of intense rainfall. Some, such as the Matenoi River on south Malekula and the Teouma River just east of Port Vila on Efate, run through impressive limestone gorges. There is only one significant floodplain the country, which is formed by rivers

[382] UNEP (2005). *State of Environment Report – Vanuatu*. https://www.unep.org/resources/report/state-environment-report-vanuatu. Accessed 30/08/2023

[383] Kalfatak, D. and Jaensch, R. (2014). Directory of Wetlands of Vanuatu - 2014. Report to the Secretariat of the Pacific Regional Environment Program. https://library.sprep.org/content/directory-wetlands-vanuatu-2014. Accessed 25/08/2023.

draining from the Tabwemasana Mountain Range in the center of Espiritu Santo into Big Bay on the north coast.

The onshore and offshore geology of the islands to the north of Efate have been mapped,[384] though geological surveys of the southern islands, with the exception of Efate (Figure 79), are not available. The islands that have been mapped show a range of mineral deposits, ranging from submarine volcanic rocks and gravelly marine sand in some areas to limestone and lignite in others.[385] The geographic distribution of these resources is summarized in Table 40.

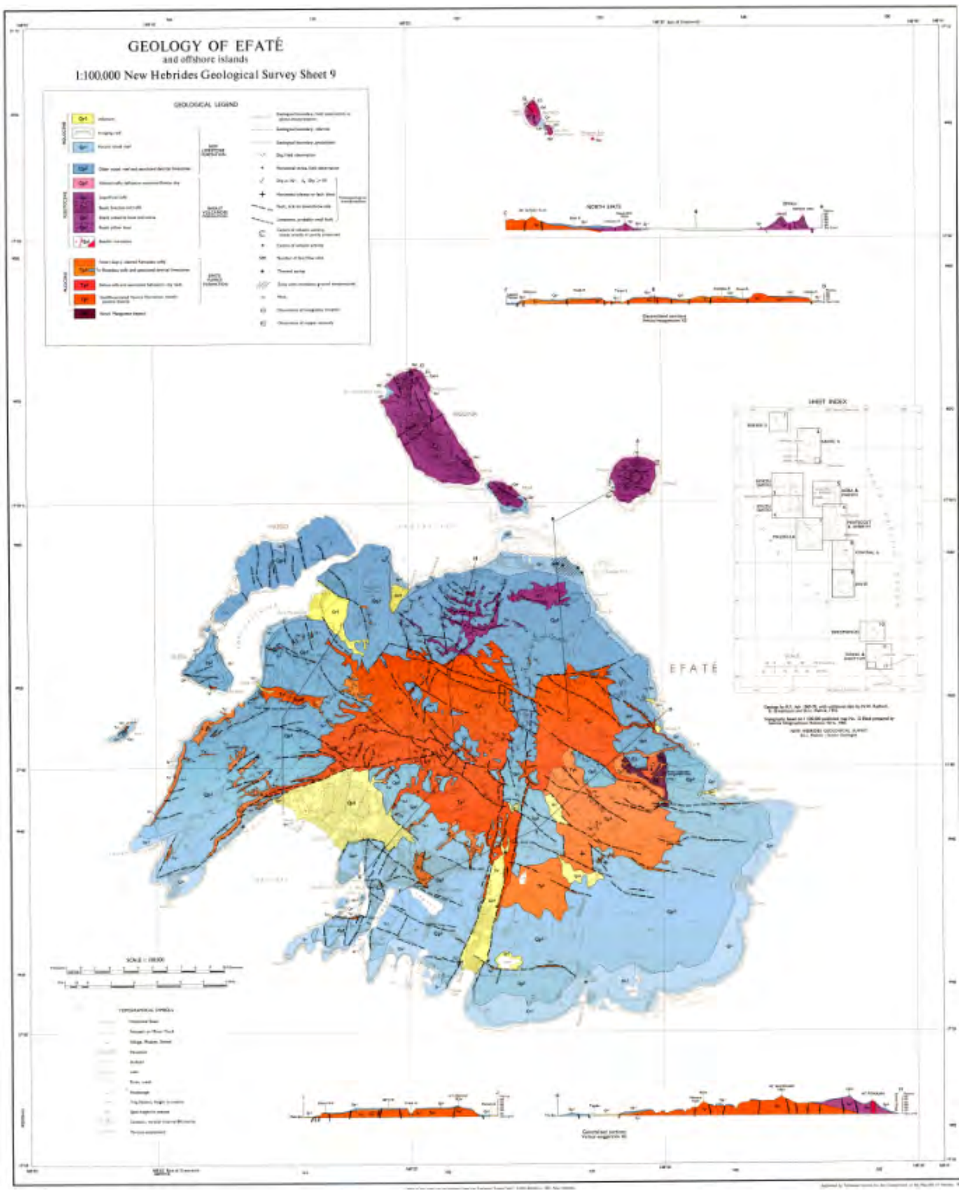
Table 40: Onshore and Offshore Geology of Islands North of Efate

Island	Predominant geology
Epi	Onshore volcanic rock and offshore submarine volcanic rock in surrounding waters.
Ambrym	Onshore volcanic rock, offshore submarine volcanic rock, fluvio marine deposits offshore to the south with basinal and shelf deposits to the north.
Malekula	Significant areas of uplifted limestone shelf along the coast. Large areas of inland Ora Limestone and volcanic rock with smaller areas of greywacke (sandstone containing >15% clay)
Pentecost	Predominantly calcarenite, calcilutite and biocalcarenite. Thin strips of limestone shelf on east coast, small areas of red mudstone in the south, and offshore globigerina ooze, calcarenite, calcilutite and volcanic rocks to the west.
Maewo	Comprised of mostly raised limestone areas, and onshore and offshore (to the west and north) globigerina ooze, calcarenite, calcilutite, and volcanic rock.
Aoba	Volcanic rock with surrounding fluvio marine deposits, basinal shelf deposits and unstable marine slope deposits.
Espiritu Santo	Large areas of east and southeast contain raised limestone reef. Parts of central region contain conglomerate gravelly sand, while northwest of the island has range of volcanic rock, lignite, limestone, and igneous intrusions. Southwest areas characterized by Ora Limestone, volcanic rock, and a range of globigerina ooze, calcarenite, and calcilutite.
Gaua	Onshore and offshore submarine volcanic rock.

Source: adapted from Green and Wong 1988

[384] Green, H.G. and Wong, F.L. (1988). Geology and Offshore Resources of Pacific Island Arcs – Vanuatu Region. Circum-Pacific Council for Energy and Mineral Resources, Houston, Tex.
[385] Ibid.

Figure 79: Geological Map of Efate and Offshore Islands



Source: Mallick, D.J. (1973). Geology of Efate and Offshore Islands. New Hebrides Geological Survey Series 9. High resolution map available from authors.

3.14.2 Summary of aggregate extraction sites and known resources

The main types of aggregate for the construction and infrastructure sectors in Vanuatu are coronus material in the form of uplifted weathered limestone, volcanic rock (pumiceous), coastal sand, and riverine deposits of sand and gravel. On Efate Island, the predominant source of aggregates is coronus limestone material extracted from quarries and crushed into different sizes on site, depending on end use. Sources of accessible quality volcanic rock are limited to the center and north of the island, with a previously operational quarry at Quoin Hill on the north coast. Some studies, however, indicate that rock deposits would not sustain a medium- to large-sized quarry operation on Efate.[386] There are,

[386] Tawake, A., Garae, C., and Sharma, A. (2008). Proceedings of the Vanuatu National Coastal Resources Management Workshop: "Planning and Policy Frameworks for Coastal Resources Management with an emphasis on Sustainable Development and Management of Aggregates". EU-SOPAC. https://purl.org/spc/digilib/doc/kp4nj. Accessed 25/08/2024.

however, potentially good deposits of volcanic rock on the nearby volcanic islands of Nguna, Emao, and the Shepherd Islands.

Figure 80: Limestone Boulders at a Quarry in Efate

Photo: Paul Rogers, UQ 2023

The Public Works Department (PWD) of the Ministry of Infrastructure and Public Utilities is a major user of aggregates for road construction and maintenance and other public works. As of August 2023, its database showed that along with the Vanuatu Transport Sector Support Program (now known as the Roads for Development Program) it has used around 201 quarries across the country since 2012 when the database was established. Information on the type of aggregate is available for only 148 of these quarries. Only 28 quarries have current valid permits with the rest having expired. It should be noted that 41 of the permits expired in 2023 and some of these quarries may still be operating or in the process of renewing their permits. In addition, there are no permit data at all for 70 quarries, so it is possible information has not been entered into the database yet and these could feasibly have current and valid permits. Table 41 summarizes the location of these quarries, type of aggregate resources available, and permit status.

Table 41: Summary of Aggregate Resources Used by the Public Works Department across the Country

Island	Type	Number of quarries	Number of active permits
Ambae	Volcanic scoria	7	0
	Sand, coral	1	0
	Sand	2	0
	Unknown	2	2
Aneityum	Unknown	1	0
Efate	Unknown	1	0
Emae	Limestone	1	0
Epi	Limestone	2	0
	Limestone, coral	5	0
Eromango	Unknown	2	2
Maeowo	Limestone	22	0
Malekula	Limestone	20	0
	Limestone, boulders	1	0
	Coral	1	0
	Sand	2	0
Malo	Limestone	9	0
	Sand	1	0
	Unknown	7	7
Moto Lava	Limestone	1	0
	Unknown	2	0
Pentacost	Limestone	23	0
	Sand	1	0
	Unknown	16	0
Santo	Limestone	28	8
	Unknown	6	6
Tanna	Limestone	11	0
	Sand	1	0
	Unknown	2	1
Tongoa	Tuff	2	0
Vanua Lava	Limestone	5	0
	Unknown	3	2
Total		**201**	**28**

Source: Vanuatu Public Works Department database, August 2023

Annual extraction limits of 40,000 m^3 are set for most these quarries, though there are no data available to indicate how much has been extracted. The large number of quarries, many of which have expired permits, suggests many are borrow pits for road and other infrastructure projects around the country.

The PWD's quarry database does not include quarries where private commercial entities have entered into a landowner agreement to extract aggregates. Information about these quarries has been requested from the Department of Geology and Mines. So far, aggregate production data by island has been provided, though not information on how many sites or quarry operators there are.

These are summarized in Table 42. Most of the aggregate is limestone, followed by sand. Interestingly, there is also a small amount of basalt extraction on Espiritu Santo, river stone, and pebbles/cobbles.

Table 42: Aggregate Production in Vanuatu, 2020–2023 (m^3)

	Limestone	Sand	Basalt	River stone	Pebbles/cobble
Efate	113,182	8,500			
Santo	72,017	10,444	1,000		
Pentecost	36,457	100			500
Aore	0	500			
Malekula	89,650	500			
Ambrym	0	170			
Paama	0	350		1,000	
Tanna	5,800				
Total	**317,106**	**20,564**		**1,000**	**500**

Source: Vanuatu Department of Geology and Mines, August 2023)

However, a recent field excursion to Efate in August 2023 revealed that there are currently five commercial limestone quarries operating. One of these located not far from Port Vila is shown in Figure 81.

In addition, previous studies have documented coastal sand resources on the south of Efate, as well as a non-operational hard rock quarry in the north.[387] Extraction of sand resources has had significant adverse environmental impacts in the past but continues on Efate, with production of around 8,500 m^3 between 2020–2023. Sand is also extracted in several other islands, as shown in Table 42.

Consultations in Vanuatu reveal that there are currently no operational hard rock quarries in Vanuatu; however, data provided by the Department of Geology and Mines indicate basalt production of 1,000 m^3 in Espiritu Santo as recently as 2020, though nothing since. This has necessitated the import of hard rock aggregate for use in asphalt concrete and double bituminous surface roads, for which limestone aggregate found in Vanuatu is not suitable. This limestone is also not suitable for concrete structures. Most of this aggregate has been imported from Fiji, PNG, New Caledonia, and the north Pacific/Asia. One government official stated that Vanuatu currently imports 30–40% of its aggregate needs.[388]

[387] Tawake, A., Garae, C., and Sharma, A. (2008). Proceedings of the Vanuatu National Coastal Resources Management Workshop: "Planning and Policy Frameworks for Coastal Resources Management with an emphasis on Sustainable Development and Management of Aggregates". EU-SOPAC. https://purl.org/spc/digilib/doc/kp4nj. Accessed 25/08/2024. [388] Personal Communication in Vanuatu. Dated 22/08/2023.

Figure 81: Commercial Limestone Quarry in Efate

Photo credit: Paul Rogers, 2023

Table 43: Sand and Basalt Aggregate Resources on Efate

Location	Type	Activity	Description
		Efate	
Mele Bay / Blacksands	Lagoon/ coastal	Extraction previously banned – current status unknown	Extraction of sand undertaken by local community but has since stopped due to coastal erosion. Sand is rich with pumice fragments. However, pumice is a light, highly porous, and weak volcanic rock that could weaken the strength of concrete if used in large quantities for construction. High salt content due to level of porosity, which can also potentially lead to concrete expansion and cracking over the long term. Total ban on sand extraction due to coastal erosion and other issues in 2005 but local landowners can extract sand to build their own houses but not sell. Sand mining reopened again later.
Teuma Bay	Lagoon/ coastal	Status unknown	Sand mining opened by Dept of Geology and Mines in response to closing of nearby Mele Bay in 2005. Like Mele Bay, sand is high in pumice fragments. Significant coastal erosion problems resulting from extraction documented in 2007, as well as disputes between operators and landowners. Due to the relatively small size of the Teuma River, the sediment replenishment rate is much less than Mele Bay and overexploitation has

Location	Type	Activity	Description
			led to the recession of the coastline which has reached a critical stage.
Teae River mouth	Lagoon/ coastal	Status unknown	Better quality sand derived from the Teae River catchment on the western coast of Mele Bay. High occurrence of volcanic rock fragments, obsidian, and felsic minerals.
Quoin Hill	On-land basalt deposit	Potential source of aggregates (currently not operational)	Volcanic rock outcrops located in North Efate. Basalt is good quality – fresh, strong, and durable but of insufficient quantify to open a medium to large size quarry. The vesicular basalt flow may require additional tests if they are to be used for high performance applications (e.g., asphalt for airport runways).

Source: Tawake, A., Garae, C., and Sharma, A. (2008). Proceedings of the Vanuatu National Coastal Resources Management Workshop: "Planning and Policy Frameworks for Coastal Resources Management with an emphasis on Sustainable Development and Management of Aggregates". EU-SOPAC. https://purl.org/spc/digilib/doc/kp4nj. Accessed 25/08/2024.

In the private commercial quarries at least, limestone is washed to remove salt and fines and then screened and crushed on site, as shown in Figure 82.

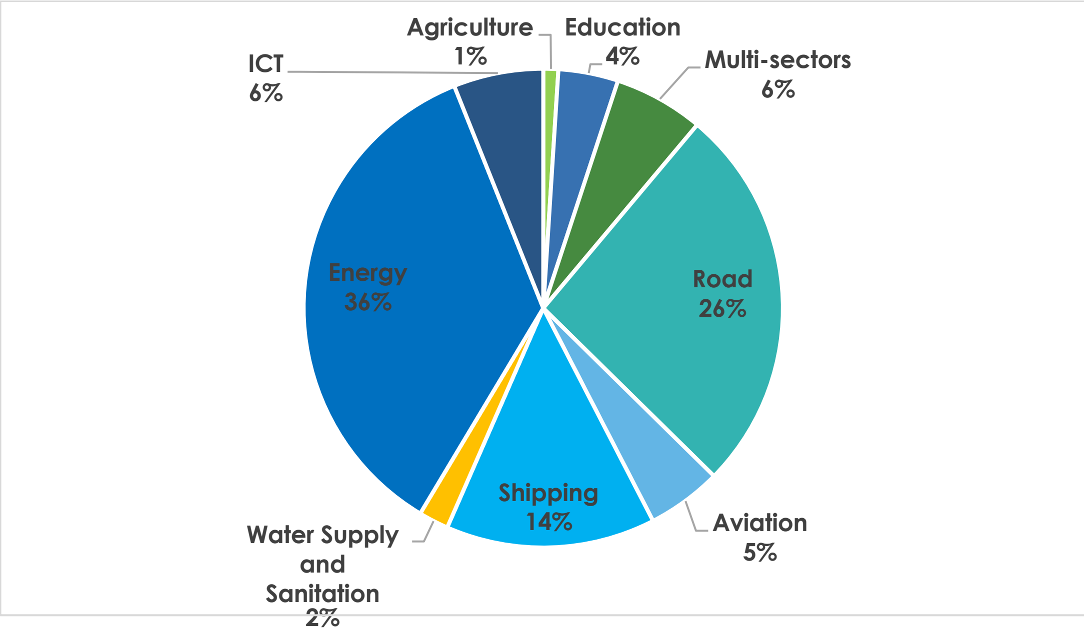
Figure 82: Workers Washing Crushed Limestone Aggregate at a Quarry in Efate

Photo credit: Paul Rogers, UQ 2023

3.14.3 Aggregates required for infrastructure development

The Vanuatu Infrastructure Strategic Investment Plan 2015–2024 sets out strategic infrastructure investments for the country. The authors of the plan stated that as of 2015, the respective line Ministries do not yet have "clear infrastructure development and management plans that anticipate infrastructure needs, set priorities, and estimate budget requirements that take into account the need for sustainable operation and management."[389] The plan set about rectifying this and short-listed infrastructure investments across a number of sectors, as shown in Figure 83. The largest of these included roads, energy infrastructure (e.g., geothermal power plants) and shipping (e.g., wharfs). Projects were categorized into; Individual Public Investment Projects (estimated investment value of $225 million); Bundled Public Investment Projects (estimated investment value of $73 million); and Private Public Investment Projects (estimated investment value of $108 million). At the time of writing, it is not known how many of these projects have been funded or are in the process of development.

Figure 83: Short-listed Infrastructure Investments, 2015



ICT = information and communications technology.

Source: Government of Vanuatu

In 2023, PRIF identified key projects in Vanuatu.[390] These are listed in Table 44, which also assesses the level of aggregate demand for projects based on the type of infrastructure to be developed.

[389] Government of Vanuatu (2015). Vanuatu Infrastructure Strategic Investment Plan 2015–2024. https://www.theprif.org/country-profile/republic-vanuatu. Accessed 01/08/2023.

[390] Pacific Regional Infrastructure Facility (2023). PRIF Infrastructure Pipeline Projects. Internal report.

Table 44: Infrastructure Projects Identified by Pacific Regional Infrastructure Facility and Expected Aggregate Demand

Sector	Project Name	Budget ($M)	Expected Aggregate Demand	Assumptions
Transport	Transport Interisland Shipping Support Project (second additional financing)	65.2	High	Large quantities may be needed but will depend on nature of project, i.e., wharfs will require lots of concrete.
Transport	Outer Island Maritime Project	30	Medium to High	Large quantities may be needed but will depend on nature of project, i.e., wharfs will require lots of concrete.
Energy	Renewable Energy Systems in Efate and Tanna	15	Medium	Pending project details
Urban Development/ Water and Sanitation	Luganville Urban Water Supply and Sanitation Project	43.9	High	Urban water supply and sanitation infrastructure requires lots of concrete and, hence, hence aggregate.
Urban Development	Greater Port Vila Urban Resilience Project – Additional Financing – tentative	15	to be calculated	Pending project details
Urban Development	Port Vila Courthouse (w/DFAT)	2	Low-medium	Relatively small project
Total ($)		**171.1**		

DFAT = Australia Department of Foreign Affairs and Trade.

Source: PRIF, 2023

3.14.4 Overview of the legal and policy framework

Land and resource ownership

Vanuatu's Constitution, which came into effect at independence in 1980, states that "All land in the Republic of Vanuatu belongs to the indigenous custom owners and their descendants" and that the rules of "kastom form the basis of land ownership and use in Vanuatu."[391] Under *kastom*, individual, family, and clan identity are fundamentally connected with the land, which forms an intrinsic part of ni-Vanuatu culture, power, and spirituality.

Around 99% of all land is held under customary tenure while the remaining 1% is held by the government for public purposes and urban land.[392] Customary land can be leased for a maximum period of 75 years and may be used for commercial / tourism, agricultural, industrial, and other activities. Around 9% of all customary land is leased for such purposes, while the remaining 90% is

[391] Articles 73 and 74 of Vanuatu's Constitution; *Kastom* refers to the norms of behavior, values, and structures that govern relations between people.

[392] SPC/GIZ (2014). Vanuatu: Legal Framework for REDD+. *SPC/GIZ Regional Project* "Climate Protection through Forest Conservation in Pacific Island Countries". https://vanuatu-data.sprep.org/system/files/20140827_Vanuatu%20legal%20framework%20for%20REDD_web.pdf. Accessed 15/08/2023

unleased and cannot be sold to foreigners. However, customary land may be alienated (e.g., sold, mortgaged, etc.) to other ni-Vanuatu if local customary law permits.[393]

Land Reform Act 1980

The Land Reform Act came into effect shortly after independence as an interim measure to implement the land matters addressed in Chapter 12 of Vanuatu's new constitution. Its provisions cover definitions (e.g., of parties involve in land affairs), alienation, encumbrances, negotiations and agreements, land management, public land and compensation, leases, and other matters. Many of these provisions have been revised under subsequent legislation, as discussed below.

Land Acquisition Act 1992

The powers of the state to acquire land in the public interest are provided by the 1992 Land Acquisition Act. This act sets out the procedures the state must follow to acquire land. The first step is for the Minister of Lands to define why acquisition is "necessary or expedient in the public interest". This is followed by series of sequential steps: land investigation, notification of landowners of intended acquisition by the state, appeals, inquiry into compensation, further appeals, payment of compensation and then possession.[394] In addition to compensating landowners for the land, payments may also made for any damage incurred during the land investigation. The act has reportedly been used successfully many times with agreement reached on compensation.[395]

Alienated Land Act 1982 (amended 2000)

The Alienated Land Act enables customary owners to lease parts of their land for a maximum period of 75 years (see discussion above), including to foreigners. Those who want to lease the land, whether an individual or group, must first apply for a Certificate of Registered Negotiator, which is issued by the Minister of Lands and allows the lessee to negotiate with the customary landowners to obtain a lease.[396]

The act also enables the government to hold a perpetual lease on urban land and land used for a public purpose, though customary owners are entitled to an ongoing share of any revenue generated and can also continue to occupy some of the land.

Land Leases Act 1983

The Land Leases Act 1983 makes provisions for registering leases.[397] Under the act, the term "lease" is defined as the grant "by the owner of the land to the exclusive possession of his land" and the lessor as "the person who has granted a lease or his successors in title".[398] However, these

[393] Ibid.

[394] Manning, M. and Hughes, P. (2008). 'Acquiring land for public purposes in Papua New Guinea and Vanuatu', in Making Land Work, Volume 2, Case Studies Australian Agency for International Development. https://www.dfat.gov.au/about-us/publications/Pages/making-land-work. Accessed 30/08/2023.

[395] Lunnay, C., Fingleton, J., Mangawai, M., Nalyal, E. & Simo, J. (2007). *Vanuatu—Review of National Land Legislation, Policy and Land Administration*. Report prepared for AusAID.

[396] Manning, M. and Hughes, P. (2008). 'Acquiring land for public purposes in Papua New Guinea and Vanuatu', in Making Land Work, Volume 2, Case Studies Australian Agency for International Development. https://www.dfat.gov.au/about-us/publications/Pages/making-land-work. Accessed 30/08/2023.

[397] Land Lease Act. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC088905. Accessed 30/08/2023.

[398] Lunnay, C., Fingleton, J., Mangawai, M., Nalyal, E. & Simo, J. (2007). *Vanuatu—Review of National Land Legislation, Policy and Land Administration*. Report prepared for AusAID.

definitions do not acknowledge that the land is under customary ownership in rural areas or in urban areas, under state ownership. The act covers registration, dispositions, leases, mortgages, transfers, easements, and subdivisions etc. It also specifies that upon registration, the rights of the customary landowner are indefeasible and are held "free from all other claims and interests whatsoever" (section 15). Notable provisions of the act include a requirement for the lessee to seek the consent of the lessor if land is to be sold, though consent cannot be "unreasonably withheld". Other notable provisions are that "every lease must specify the purpose and use for which the land is leased" (section 38) and "provision is made for regular rent reviews" (section 39).

The Land Leases Act has undergone several amendments since it was passed into law, the most recent of which was in 2017.[399] Among other changes, this amendment gave the Director the power to cancel a lease from the register relating to land which has been acquired under the Land Acquisition Act. Other key amendments occurred in 2003, which allows leases of land for public purposes to be extended to 75 years on receipt of a payment, and one in 2004 that introduced a new formula for calculating the payment.[400]

Custom Land Management Act 2013

It has been suggested that one of the major obstacles to development in Vanuatu is land access and development, especially on customary land with disputes between landowners and potential developers or among different landowners being common.[401] Article 78 of the Constitution requires the government to "arrange for appropriate customary institutions or procedures to resolve disputes concerning the ownership of custom land". It required the government to put in place a land dispute settlement system. The most recent law dealing with land disputes is the Custom Land Management Act of 2013 (amended in 2014). This act empowers customary institutions, known as *nakamals*, to make decisions about who are the customary owners of specific areas. The *nakamals* are also empowered to resolve boundary disputes and decisions should be accompanied by a sketch of the land area(s) that identify landmarks to confirm boundaries.[402] The final decision on land ownership is put in writing and entered into central land database. It is a legally binding decision that can only be challenged on very limited grounds, for example in the case of fraud. The act also establishes a National Coordinator of Land Dispute Management (Section 10).

Policies

National Sustainable Development Plan, 2016-2030

The National Sustainable Development Plan (NSDP), or the "People's Plan" is the country's highest level development plan. It describes the country's vision and overarching policy framework "for achieving a Stable, Sustainable and Prosperous Vanuatu within the next fifteen years, and in doing

[399] Food and Agriculture Organization of the United Nations. Amendments of the Land Leases Act (CAP 163) https://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=VUT

[400] Manning, M. and Hughes, P. (2008). 'Acquiring land for public purposes in Papua New Guinea and Vanuatu', in Making Land Work. Australian Agency for International Development. Making Land Work | Australian Government Department of Foreign Affairs and Trade Accessed 30/08/2023.

[401] Tawake, A., Garae, C., and Sharma, A. (2008). Proceedings of the Vanuatu National Coastal Resources Management Workshop: "Planning and Policy Frameworks for Coastal Resources Management with an emphasis on Sustainable Development and Management of Aggregates". EU-SOPAC. https://purl.org/spc/digilib/doc/kp4nj. Accessed 25/08/2024.

[402] SPC/GIZ (2014). Vanuatu: Legal Framework for REDD+. *SPC/GIZ Regional Project* "Climate Protection through Forest Conservation in Pacific Island Countries". https://vanuatu-data.sprep.org/system/files/20140827_Vanuatu%20legal%20framework%20for%20REDD_web.pdf. Accessed 15/08/2023

so sets out the national priorities and context for the implementation of the new global Sustainable Development Goals over the same period".[403] Responsibility for monitoring and evaluating implementation of the NSDP lies with the Department of Strategic Policy, Planning and Aid Coordination together with the Vanuatu National Statistics Office and other key government agencies. The plan is built around three pillars outlining goals, policy objectives, indicators, and targets for achieving the "People's Plan" vision of sustainable development.

Climate Change and Disaster Risk Reduction Policy

In common with other Pacific islands, addressing the risks of climate change is one of Vanuatu's highest priorities. The Climate Change and Disaster Risk Reduction Policy recognizes that Vanuatu is one of the most vulnerable countries in the world to climate change and natural disasters, such as earthquakes, tsunamis, volcanic eruptions, and pandemics. The policy provides a framework through which risks can be identified, assessed, reduced, and managed. Its vision is for Vanuatu's communities, environment, and economy to be resilient to the impacts of climate change and natural disaster risks.

The policy outlines Vanuatu's vision, principles, strategic goals, priorities and strategies for climate change and disaster from natural hazards risk reduction. The government has identified six priority areas to focus on, which fall into two categories, i.e., systems and themes. Systems include governance, finance, knowledge, and information, while themes include climate change adaptation and disaster risk reduction, low-carbon development, and response and recovery. In implementing these priorities, the government collaborates with a range of international partners and is a party to various international frameworks and conventions, such as the United Nations Framework Convention on Climate Change.

Vanuatu National Land Use Planning and Zoning Policy

This policy aims to guide land use planning by setting priorities and outlining legislative and institutional structures that encourage the best current use of Vanuatu's land resources to achieve "An Educated, Healthy and Wealthy Vanuatu", while also ensuring future generations will equitably benefit from the same resources. This Policy serves as framework for land use planning that covers all land, from rural communities to urban centers.

National Biodiversity Strategy and Action Plan

Vanuatu's first National Biodiversity Strategy and Action Plan was endorsed in 1999 and revised in 2018 to cover 2018–2030. The revised plan has seven strategic areas:

1) Conservation Area Management
2) Forest and Inland Waters and Ecosystems Conservation and Management
3) Coastal and Marine Ecosystems Conservation and Management
4) Species and Genetic Diversity Conservation
5) Invasive Species Eradication and Control
6) Mainstreaming Biodiversity across sectors and society
7) Resource Mobilization

The plan includes provincial-level implementation plans that address threats to Vanuatu's biodiversity. It also identifies potential conservation areas within which local communities can participate.

[403] National Sustainable Development Plan 2016 – 2030 (p1). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC169232. Accessed 13/08/2024.

Legal framework for the aggregates sector

Mines and Minerals Act 1986[404]

Responsibility for administering the Mines and Minerals Act lies with the Ministry of Land and Natural Resources. The act makes provision for the control and administration of mining and related operations in Vanuatu.[405] It contains 90 sections divided into 19 parts. Part 2 states that all minerals are vested in the Republic of Vanuatu. This includes onshore resources as well as the seabed and subsoil of the continental shelf and within Vanuatu's exclusive economic zone. Part 15 deals with Financial Provisions and Royalties, including royalty payments to the state and customary landowners. Other provisions of note deal with Mining Licenses (Part 9), Quarry Permits (Part 14), and Restrictions and Surface Rights (Part 16).

Quarry Act 2013 (amended 2016)

This act makes provision for the regulation of quarries, including the extraction of aggregates and other building minerals, and related operations. It encompasses the following matters: functions and powers of the Commissioner (of Mines) (Part 2), appointment, functions, and powers of authorized officers (Part 3), aggregate prospecting and quarry permits (Part 4), roles and responsibilities of quarry foremen (Part 5), establishment and governance of a quarry board (Part 6), employment and accidents (Part 7), royalties (Part 8), and other matters.

Provisions of note are the type of quarry permits that the Commissioner can issue, which include Commercial Permits, Landscaping Permits, Public Works Permits, and Occasional Permits, the latter issued for a period of one month only and are usually associated with one-off projects. Quarries used by the Department of Public Works and Utilities to extract aggregates for road works would require a Public Works Permit (but would not require payment of a permit fee), while commercial operations, which may be more permanent, would require a Commercial Permit.

The act also categorizes quarry size and sets time periods for each type of permit, as well as the volume of material that can be extracted per year. The Quarry Act was amended in 2016 with additional provisions, including among other things, those dealing with environmental protection, disputes between customary owners, and suspension of a quarry permits.

Quarry Permit Regulation Order No. 8 of 2005

This regulation makes provision for applications for the issue of Quarry Permits and for related matters. It outlines the steps required to obtain a permit which include things such as details of the quarry area, mineral to be extracted, including an estimate of the quantity in cubic meters to be extracted, submission of an OHS management plan, an environmental management plan, and various other mandatory steps. The permit regulation also describes the form and conditions of quarry permits, fees, revocation and suspension, reports on the amount and type of mineral extracted, permit relinquishment, land restoration, and other matters.

[404] Copies and summaries of the various acts described in this section were obtained through the FAOLEX database. See https://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=VUT. Accessed 30/08/2023.

[405] Food and Agriculture Organization of the United Nations. Vanuatu Mining and Minerals Act (1986). https://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=VUT. Accessed 30/08/2023.

Other relevant legislation

Environmental Management and Conservation Act 2002 (amended 2010)

This act concerns the sustainable development and environmental management of Vanuatu, and the regulation of related activities.[406] The act contains 45 sections divided into six parts dealing with its administration including the appointment, role, and powers of a director; requirements and procedures for environmental impact assessment of projects, proposals, or development activities; biodiversity and protected areas; the identification and registration of community conservation areas; handling of environmental and conservation offences; and other matters such as the power of the Minister to make regulations that support the purposes and provisions of the act.

An amendment in 2010 changed the act's name to Environmental Protection and Conservation Act. This act formally established the Department of Environmental Protection and Conservation (DEPC) and outlines its role in the development, coordination, and implementation of the government's environmental policies and programs.[407] A number of additional provisions were also inserted into the act, including definitions of "biodiversity significance", "climate change", "conservation area", "EIA review committee", "preliminary environmental assessment", "significant environmental impact" and others matters. Notable among these other matters are updates to community conservation matters, as well as requirement for the director to obtain the consent of customary landowners for projects and development activities on customary land, rather than simply negotiating with them (Section 35).

Environmental Impact Assessment Regulations 2011 (amended 2012)

These outline when PEAs and EIAs are required, the roles and responsibilities of different stakeholders, including the director of the DEPC and how they should be conducted as required under the EIA provisions of the Environmental Protection and Conservation Act (Part 3). Projects, proposals, or development activities subject to the PEA and EIA provisions are specified in Schedule 1 of the regulations. The EIA report must be accompanied by an environmental management and monitoring plan.

Project proponents are required to conduct public consultations, while the department may carry out compliance and monitoring inspections. In addition, the department will also conduct an annual environmental audit of projects that have been granted EIA approval.

3.14.5 The institutional and operating framework

Ministry of Lands and Natural Resources

The Ministry of Lands and Natural Resources is comprised of the Department of Lands and Department of Water, Geology, and Mines, and Office of the Valuer General. It is responsible for ensuring these departments implement and ensure compliance with relevant legislation, such as the Mines and Minerals Act and Custom Land Management Act (see sections 1.4 and 1.6). It also works in collaboration with other Ministries, such as the Ministry of Internal Affairs to deal with land issues.[408]

The ministry's primary objectives are:

[406] Department of Environmental Conservation. https://environment.gov.vu/index.php/environment-conventions-and-agreements/laws/laws-depc/epc-act. Accessed 30/12/2023.

[407] Vanuatu Department of Environmental Protection and Conservation. https://environment.gov.vu/index.php/about-us.

[408] Vanuatu Ministry of Lands and Natural Resources. https://mol.gov.vu/index.php/en/.

1. Ensuring there are fair dealing in lands, and
2. Ensuring that the rights of Custom Owners to their lands, and its developments, are fully recognized and protected.

Department of Lands

The role of the Department of Lands is to facilitate and manage land-related issues in Vanuatu. The department is comprised of the Land Survey Section, the Land Section, and the Land Records Section. Together, these are responsible for land planning and enforcement, execution of leases, land valuation, land surveys, and land registration.[409] An important part of the department's mission is to facilitate the resolution of land disputes and to manage land and its resources to promote the economic and social well-being of Vanuatu.

The Department of Geology, Mines, and Water

This department is responsible for promoting and managing mineral resource exploration and exploitation with the aim of improving the well-being of Vanuatu's people.[410] It also works closely with international organizations such as SPC to achieve its mission and objectives. Its mission is to ensure that petroleum, geothermal, and mineral resources are exploited in a way that contributes to Vanuatu's economy and social living conditions and that the environment is protected in the process. Its objectives are to enhance the department's institutional capacity and develop geo-scientific information systems and evaluation of resource potential.

The department is responsible for issuing mining permits[411] as well as monitoring compliance with permit conditions. It is also responsible for issuing quarry permits, including a Quarry Permit that waves any fees for the PWD. The department is headed by a commissioner.

Ministry of Infrastructure and Public Utilities

With responsibilities for overseeing the development and maintenance of Vanuatu's roads and other infrastructure, the Ministry of Infrastructure and Public Works is a major stakeholder in the quarry/aggregates sector in Vanuatu. It comprises the Civil Aviation Authority of Vanuatu, Department of Ports and Marine, and the PWD.[412] The PWD, in particular, is the single largest consumer of aggregates in the country; as discussed, it utilizes or has utilized the aggregate resources from 201 quarries across the country since 2012, with much of this for road projects. The Ministry's mandates include, among other things, maintaining and upgrading transport networks throughout the country and providing leadership, governance, and the legal framework for infrastructure development.

Public Works Department

The primary role of the PWD is to manage, maintain, and develop the country's major national transport infrastructure assets, namely roads, ports, and airports.[413] The PWD manages the country's road network comprising over 3,000 km. In addition to ports and airports, the department also

[409] Vanuatu Ministry of Lands and Natural Resources. https://mol.gov.vu/index.php/en/about-lands.

[410] Vanuatu Ministry of Lands and Natural Resources. https://mol.gov.vu/index.php/en/department/geology-mines.

[411] Government of Vanuatu Public Works Department (2014). PWD Quarry Guide. https://pwd.gov.vu/images/PWD_Documents/Policy_and_Strategy/PWD_Quarry_Guide_booklet_Final_Version_-With_Cover.pdf. Accessed 30/12/2023.

[412] Vanuatu Ministry and Public Utilities. https://mipu.gov.vu/.

[413] Vanuatu Public Works Department. https://pwd.gov.vu/.

develops and maintains public buildings. In this capacity it is also supports the Ministry of Infrastructure and Public Works in managing the National Building Code. Its responsibilities include managing and administering matters related to building inspectors, approvals, and accreditation of building products.[414]

Ministry of Climate Change Adaptation, Meteorology & Geo-Hazards, Environment, Energy and Disaster Management

The Ministry of Climate Change Adaptation, Meteorology and Geo-Hazards, Energy, Environment and National Disaster Management (Ministry of Climate Adaptation for short) was established in 2014 to strategically align and coordinate the various departments responsible for responding to natural disasters and sustainable development.[415] These departments include the Department of Climate Change, Department of Energy, Department of Environmental Protection & Conservation, and Department of National Disaster Management. The Ministry also has a Corporate Services Unit to provide consolidated services and support to the Cabinet and departments under the Ministry.

Department of Environmental Protection and Conservation

DEPC sits within the Ministry of Climate Change Adaption and administers environmental laws and collaborates with international partners to address local, regional, and global priorities, such as those relating to protection of the country's unique biodiversity from climate change. It also plays a critical role in the development, coordination and implementation of the government's environmental policies and programs.[416] Core responsibilities include assessing the environmental impact of proposed developments, such as compliance with environmental impact assessment regulations, working with communities to establish Community Conservation Areas, supporting research on Vanuatu's environment, protecting endangered species, and working with municipal provincial governments to manage waste and pollution, including control of ozone-depleting pollutants.

Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity

The Ministry of Agriculture, Livestock, Forestry, Fisheries, and Biosecurity is a critical ministry in Vanuatu's government given the vast area of ocean within the country's boundaries and its social and economic reliance on agriculture (most of which is subsistence-based), livestock, forestry, and especially fisheries. The ministry oversees the policy framework that drives the development and growth in these sectors, including matters relating to biosecurity. It is comprised of five departments: Agriculture; Livestock; Forestry; Fisheries; and Biosecurity. The sectors covered by each of these departments may be impacted in various ways by aggregate extractive operations, such as disturbance of fisheries by sand dredging or impacts on agricultural land and forests by quarries.

Extraction site regulations and monitoring

Quarry permits

A range of laws and regulations apply to operations involving quarries and the extraction of aggregates, including those relating to environmental protection, occupation health and safety, and leasing of land, including consultation with customary landowners. The PWD has produced a

[414] Pacific Regional Infrastructure Facility (2021). Regional Diagnostic Study on the Application of Building Codes in the Pacific – Vanuatu Case Study.

[415] Vanuatu Ministry of Climate Change. https://mocca.gov.vu/index.php/about-us/who-we-are.

[416] Vanuatu Department of Environmental Protection and Conservation. https://environment.gov.vu/index.php/about-us.

Quarry Guide that illustrates the steps that government and project proponents must take before a quarry permit is granted. The objectives of the guide are to ensure that quarries or borrow pits are properly acquired, used, and rehabilitated upon completion of extractive operations. The guide also outlines the process and criteria for determining royalty payments to be provided to customary landowners and the government.

In the case of new quarries to be used by the PWD, the first step is to undertake prospecting activities. This includes assembling a team from the PWD, comprising a geologist, an engineer / Senior Road Foreman, and Manager or Technical Advisor to assist with landowner negotiations. Following the site survey, a PEA must be undertaken to determine whether a full EIA is required as determined by criteria set out in the EIA Regulations 2011. The PEA is undertaken by the director of DEPC or an authorized officer, but the typical procedure is to delegate authority for the PEA to the Department of Mines and Minerals, which is responsible for issuing quarry permits and also leading land negotiations.

Once either the PEA or EIA have been completed, the proponent, in this case the PWD, develops a Quarry Management Plan (QMP) that includes:

- evidence of landowner consent to access the site
- a site plan for the quarry
- an environmental management plan
- a rehabilitation plan
- listing of all machinery to be used for extraction
- a health and safety plan

Providing the QMP satisfactorily addresses the above requirements, the Commissioner of Mines and Minerals approves the quarry permit.

Landowner agreement

The Department of Geology and Mines leads negotiations between the government and landowners to obtain agreements for the PWD or private companies to operate of customary land. The following issues are discussed during negotiations:

- land ownership
- payment / royalties
- access
- extraction quantities
- vegetation management
- rehabilitation requirements

The agreement must be put in writing and signed by the respective landowner before a permit is granted and work begins.

Dealing with land disputes

Where land disputes exist, consent must be obtained from all disputing parties for the commencement of works, during which time local chiefs or the courts determine who is the rightful landowner. If a quarry site is considered to be in the public interest, for example, where aggregate is essential for construction of a critical road but there is no alternative site, the Minister of Lands can assume ownership under the Land Acquisition Act and approve activities.

Payment of royalties

The Mines and Minerals Act specifies that royalty payments of 40% of revenues be made by the project proponent to the customary landowners, while 20% of revenues must be paid to the local government council of the region from which the minerals have been extracted. The process is for royalties to be paid to the office of the Commissioner of Mines to be held in trust by the Department of Finance, which then pays the landowners. Royalty payments are only made when landownership and is verified by the State Law Office and the Customary Land Tribunal Unit.

4. Market and Supply Chain Analysis

Data on the volume and value of the trade in aggregates in the Pacific Islands region can be unreliable. What official data exist come from figures reported by some national statistical offices and databases such as UN Comtrade, which draws its data from such official sources.[417] However, anecdotal evidence from consultations with various stakeholders as part of this study, including major infrastructure contractors, quarry operators, and shipping companies indicates that these statistics most likely underreport the true value of the trade in aggregates in the region.

There are a few possible reasons for this. One is that the high volume of aggregate in prefabricated concrete products (up to 75% of the materials used) made in countries such as Fiji is not captured in official statistics. Another explanation may be that data on the amount of aggregate exported are not being reported accurately by exporting companies, perhaps to reduce payments of tariffs and taxes. One shipping industry stakeholder in Fiji claimed that certain categories of commodities attract a 5% export tariff, payment of which can be bypassed by simply declaring a different export code. Systems for capturing trade data in various countries may also not function effectively. This is illustrated by the disparity in figures reported by UN Comtrade, where exports to a particular country sometimes do not match imports reported by that country. Nevertheless, the official data do give an indication of the flow of the aggregate trade and major markets in the Pacific Islands region.

This section draws on publicly available data, supplemented by information derived through consultation with key stakeholders, to build a picture of the aggregates trade in the Pacific Islands region. Sections describe the main aggregate-producing countries within the region, aggregate imports from outside the region, shipping and logistics, aggregate costs and quality, and potential alternative sources of aggregate that might be used for infrastructure development.

4.1 Resource availability and regional trade

As described in the country profiles, the availability of aggregate resources varies significantly geographically given the size and geology of the Pacific Islands. In many countries, “on land” hard-rock quarries are limited and, in the case of “atoll countries” like Tuvalu, Kiribati, and the RMI, non-existent. In these countries, resources are limited to marine sand and gravel of a coralline nature, which is primarily dredged in lagoons, though environmentally damaging coral reef and beach sand mining also occurs. In other countries resources are abundant but they may still import aggregates, as is the case with PNG. Even Fiji, which is a net exporter of aggregate to other PICs, imports small quantities. In 2019, for example, it exported around 7,150 tons of pebbles, gravel, crushed stone, and sand but also imported around 1,042 tons.[418]

Possible explanations for this include that some infrastructure contractors, particularly non-Fijian companies, may have existing supply relationships with quarries or distributors in their home, or other, countries and prefer to use these resources for a variety of reasons, with cost being paramount. In other cases, the quality of aggregate available in a particular place may not fulfil tender specifications and it is necessary to look at other supplies, including those from other countries within or outside the region. For example, Tonga has significant coronus / limestone aggregate resources

[417] The UN Comtrade database compiles detailed global annual and monthly trade statistics by product and trading partner and covers 200 countries. https://comtradeplus.un.org/.

[418] UN Comtrade database, 2020 export and import data. Accessed 01/11/2023.

but not all material is suitable to produce high quality concrete.[419] In particular, the density of Tonga's aggregate varies significantly between quarries with only a limited number producing high density and medium-/high-density aggregate, with the Ahononou Quarry on Tongatapu producing the best quality.

On occasion, large shipments of aggregates are known to arrive in the region but are not picked up in official data. For instance, one of the quarries at Mt Cotton in Queensland, Australia delivered four very large shipments of aggregate totaling 90,000 tons to Vanuatu for World Bank-funded airport projects in 2017–18, yet this is not reflected anywhere in official trade data, either in Australia or Vanuatu. In this case, the aggregate was for a joint venture between the Vanuatu Aviation Investment Project and PRC contractor China Civil Engineering and Construction Corporation. How often such trade is missed is not known.

Fiji's importance as a regional supplier

According to UN Comtrade data, between 2018–2022, the total volume of aggregates imported by PICs was around 94,217 tons, with a value of around $6.2 million. Fiji was, and remains, the most important source of aggregates for the Pacific Islands region. During this period, it was effectively the only supplier of aggregates from within the region to other PICs and surpassed all foreign suppliers such as those in the PRC, Australia, and New Zealand.[420] It exported 53,806 tons of aggregates, comprising 46,502 tons of coarse aggregates (pebbles, gravel, crushed stone etc.) and 7,368 tons of sand. While exports in 2022 were only 5,635 tons, previous years have been much higher (Figure 84). For example, prior to the pandemic, in 2018, Fiji's exports were 24,359 tons; in 2015, they reached as high as 60,000 tons.[421]

The aggregate market in the Pacific is strongly driven by the development of infrastructure projects in any given year, and this likely explains the fluctuations seen in aggregate exports and imports over time. Discussions with various stakeholders indicate that Fiji's exports are once again ramping up and it remains the regional hub for aggregate supply within the region.

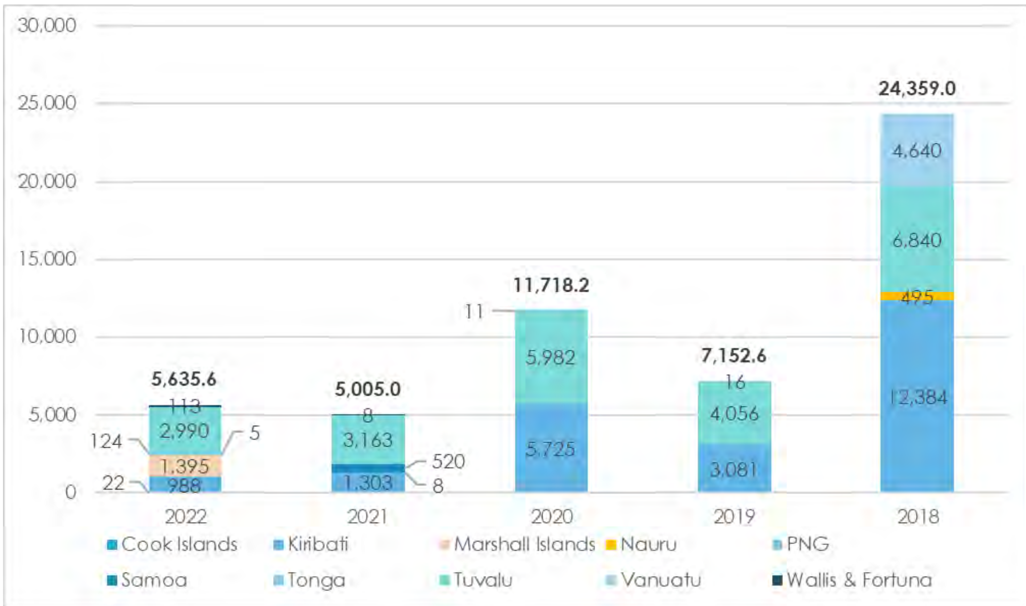
The largest markets for Fiji's aggregates in 2022 were Tuvalu (2,990 tons), followed by the RMI (1,395 tons) and Kiribati (988 tons) (Figure 84). Small quantities were also exported to Tonga (124 tons), Wallis and Fortuna (113 tons), and the Cook Islands (22 tons). Exports during 2021 were considerably smaller than previous years, most likely because of the effects of the COVID-19 pandemic.

[419] Three key characteristics of coronus material determine its quality, including cleanliness (the absence of fines within the aggregate), density and water absorption. See Candler, G.G. (1992). Engineering Testing of Building Materials in Tonga. Report prepared for South Pacific Applied Geoscience Commission (SOPAC) Technical Support Program.

[420] The one exception is Palau, which, in 2018, supplied the RMI with around 250 tons of coarse aggregate. See UN Comtrade database at https://comtradeplus.un.org/. Accessed 01/11/2023.

[421] UN Comtrade database https://comtradeplus.un.org/. Accessed 01/11/2023.

Figure 84: Fiji's Aggregate Export Markets, 2018–2022



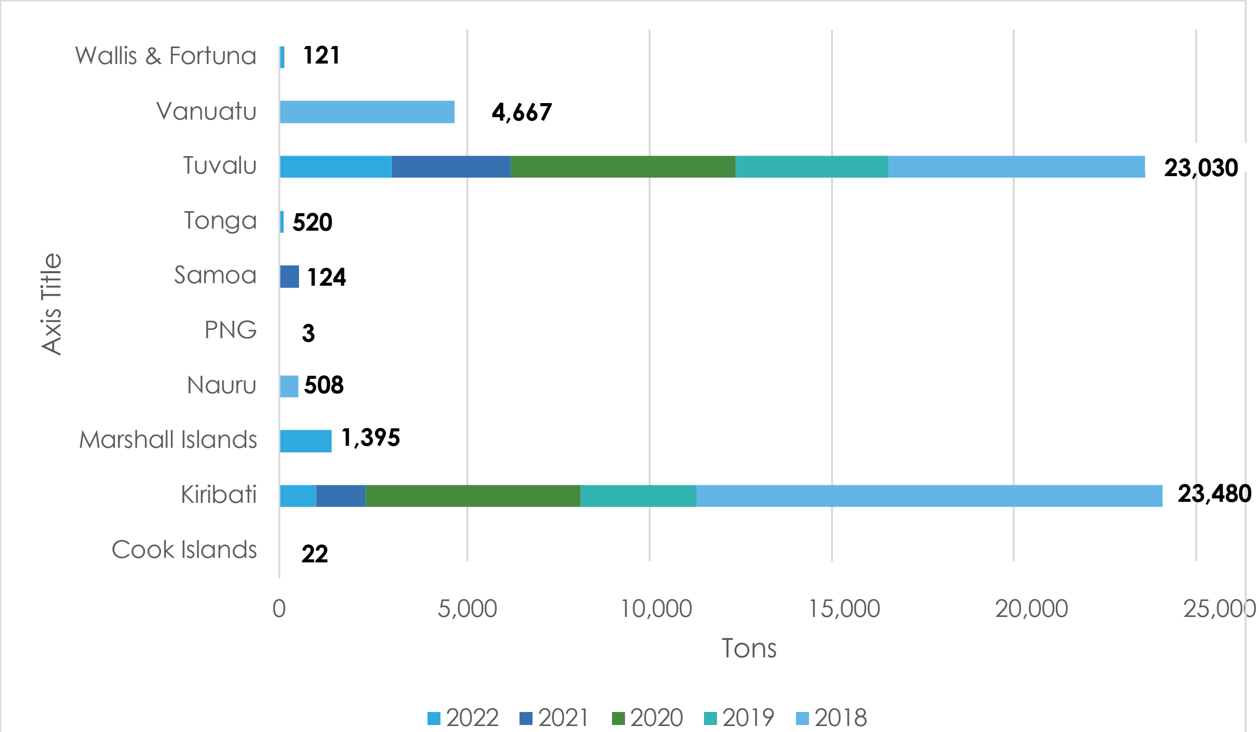
PNG = Papua New Guinea.

Source: UN Comtrade

Over the 5-year period from 2018–2022, Tuvalu and Kiribati were by far the largest export markets for Fiji's aggregates, importing 23,030 tons and 23,480 tons, respectively (Figure 85). Tuvalu and Kiribati were also the most consistent markets, importing aggregate in each of the 5 years during the period. The large quantity of imports is explained by the limited geological resources in these countries and urgent infrastructure needs, particularly in relation to climate change adaption. In Tuvalu, the main use of aggregate has been to create new elevated land, while in Kiribati it is being used for a range of construction projects, as is also the case in the RMI.[422] Other markets for Fiji's aggregates during the period are shown in Figure 85 and Figure 87.

[422] Pacific Community (2023). Marshall Islands: Identifying Aggregate Resources for Construction. https://www.spc.int/updates/blog/blog-post/2023/11/marshall-islands-identifying-aggregate-resources-for-construction. Accessed 12/11/2023.

Figure 85: Total of Aggregate Imports from Fiji by Country, 2018–2022



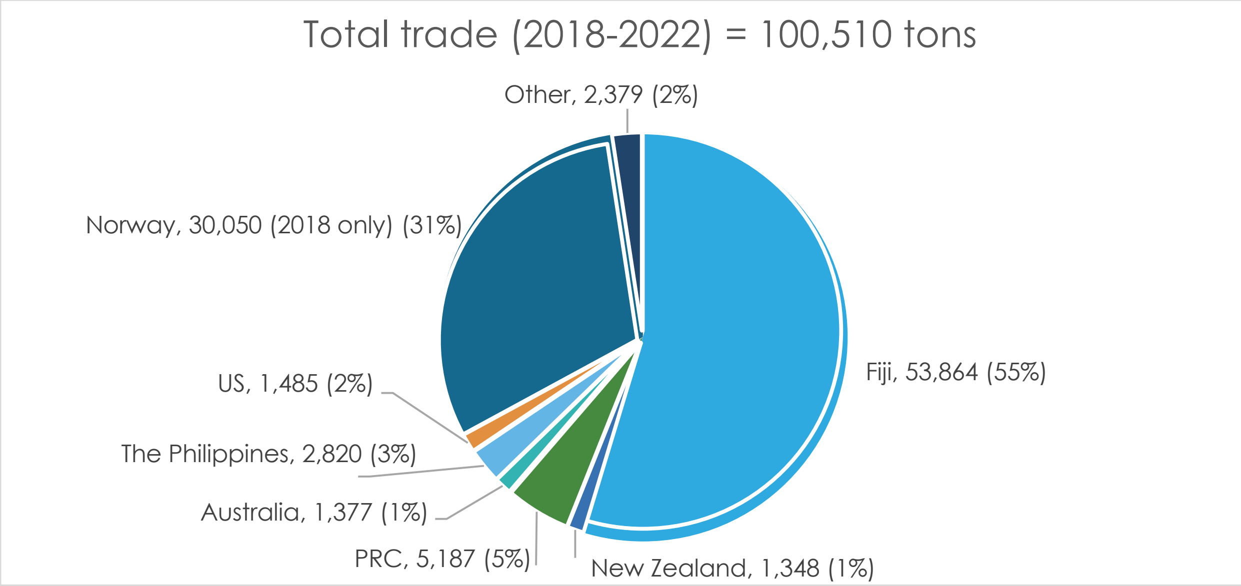
PNG = Papua New Guinea.

Source: UN Comtrade

Over the 5-year period from 2018–2022, Norway ranks as the second-largest source of aggregate after Fiji (31% of supply versus 55% for Fiji) (Figure 86), but this is entirely d ue to the very large quantity of aggregate its suppliers shipped to PNG in 2018 (30,050 tons). Excluding Norway from the analysis gives a better picture of the geography of the aggregate trade in the region. In this scenario, suppliers in Fiji account for 79% of all aggregate trade between 2018–2022, followed by the PRC (8%), the Philippines (4%), and Australia, New Zealand, and the US (1% of supply each) (PRC = People's Republic of China.). Small quantities of aggregate were also shipped from several other countries such as Malaysia, Singapore, and Türkiye.

PRC suppliers have exported to many of the region's countries during the past 5 years, including Fiji, FSM, Kiribati, Nauru, Palau, PNG, Samoa, Solomon Islands, and Vanuatu. Most supplies have been destined for Fiji but the single biggest export during the period was 4,600 tons of coarse aggregates to FSM in 2018. Supplies of aggregate from the US have exclusively been to the RMI and, most likely, given information obtained during recent stakeholder consultations, originate from one of the quarries in Guam.

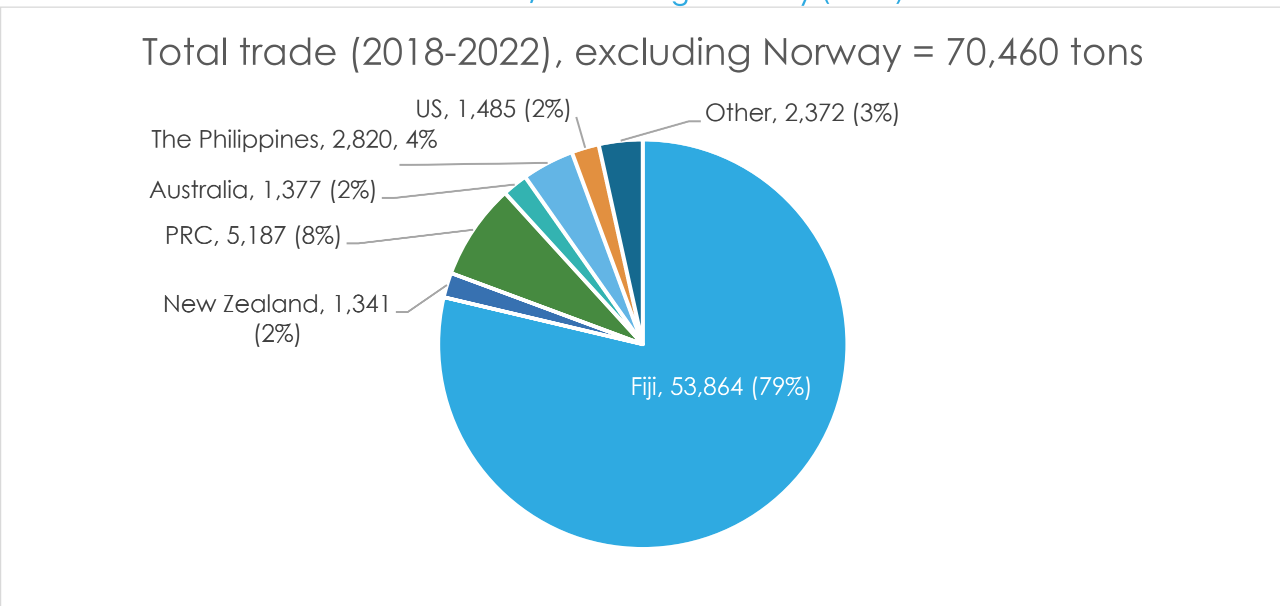
Figure 86: Origin and Quantity of Aggregates Supplied to Pacific Island Countries between 2018-2022 (tons)



PRC = People's Republic of China.

Source: UN Comtrade

Figure 87: Origin and Quantity of Aggregates Supplied to Pacific Island Countries between 2018-2022, Excluding Norway (tons)



PRC = People's Republic of China.

Source: UN Comtrade

Key suppliers in Fiji

There are no publicly available data on the quantity of aggregate exported by individual Fijian quarry owners, operators, and other aggregate suppliers. However, consultations with industry stakeholders indicate that three companies are responsible for the bulk of exports. They include Flametree Development Ltd, Gold Rock Investment Ltd, and Standard Concrete Industries Ltd, all of which are based and operate on the main island of Viti Levu. Between them they operate 14 quarries, nine of which are currently operational.[423] These companies all have crushing equipment and undertake beneficiation activities. A summary of these companies' quarry and aggregate operations is provided in Table 44.

Table 45: Summary of Quarry Operations by Fiji's Key Aggregate Exporters

Company	Quarry location	Type of quarry	Comments	No. of quarries
Flametree	Waimanu, Sawari Quarry Central Division	Hardrock		1
	Saru (Stages 1 & 2) Lautoka Quarry, Western Division	Hardrock		1
	Yanqara Quarry, Western Division	River gravel	Not yet operational	1
Goldrock	Dawasamu, Tailevu Quarry, Central Division	River gravel		1
	Qelekuro, Tailevu Quarry, Central Division	River gravel	Not yet operational	1
Standard Concrete	Nakavu, Navua Quarry, Central Division	River gravel		1
	Laqere and Nasinu Quarry, Central Division	Hardrock		1
	Lodoni, Tailevu Quarry, Central Division	River gravel	Not operational	1
	Wailotua, Wainibuka Quarry, Central Division	Hardrock		1
	Dreketi, Macuata Quarry, Northern Division	Hardrock	Not operational	1
	Lomolomo, Nadi Quarry, Western Division	Hardrock		1
	Sabeto, Nadi Quarry, Western Division	Hardrock		1
	Nadi Back Road	River gravel		1
	SCI Semo, Sigatoka Quarry	Hardrock	Not operational	1
Total number of quarries				14
Total number of operational quarries				**9**

Source: Fiji Mineral Resources Department

Flametree Development Ltd is a Nadi-based quarrying, civil works, and engineering company with three quarries in the Central and Western Divisions at Waimanu, Lautoka (Saru stages 1 and 2) and Yanqara. Stakeholder consultations indicate that Flametree is the largest exporter of aggregate to other PICs, though details about the quantity and value of its exports are not public. Flametree's Waimanu and Lautoka quarries are both hard rock, while Yanqara is a river gravel operation. The company states that its Saru hard rock quarry in Lautoka, which began operating in 2010, has some of the hardest basalt rock in Fiji and is highly in demand domestically and in other Pacific Island countries.[424] The company claims that the basalt from this quarry is the only reliable source of road-sealing chip in Fiji that complies with New Zealand Transport Agency, Fiji Public Works

[423] Mineral Resources Department, 2023 data.

[424] Flametree Developments (Fiji) Ltd. https://www.flametree.com.fj/services/quarries/.

Department, and Fiji Road Authority specifications. The company also has its own lab and states it is able to undertake a “rigorous testing and quality control regime”.

Gold Rock is family-owned Fijian quarry company established in 2016. It has a large river-gravel operation with annual production capacity of 1.2 million cubic m at Dawasamu in the Western Division and is establishing another operation at nearby Qelekuro.[425] The company is reportedly keen to take advantage of the growing demand for aggregates associated with infrastructure development in the region and has, according to shipping industry sources, purchased a tug and a 6,000-ton barge to provide better access to export markets. It is also branching out into “mountain sources” of aggregate to increase production and to fulfil major infrastructure donors’ ‘preference’ for aggregate from hard rock quarries as opposed to rivers. Gold Rock has apparently secured a lease from Fiji’s TLTB to open a new hard rock quarry inland from the Queen’s Road on the south coast close to Wainandoi.

Fiji’s third major aggregate producer and exporter is SCI, a division of Basic Industries, which is a jointly owned company of Fiji Holdings Ltd and Holcim NZ. SCI is Fiji’s largest supplier of quarried materials, ready-mix concrete, and prefabricated concrete products. It operates nine quarries, six of which are currently operational. Three of these are river gravel and sand extraction operations, including the large Navua River operation.

Data on SCI’s annual production capacity are not public but discussions with one shipping company indicate that it has shipped significant quantities of aggregate to Tuvalu in the past 3 years. The same source stated that Flametree has shipped significant quantities to both Tuvalu and Tonga during the same period. The volume of aggregate exported by Gold Rock is not known but the company has apparently made deliveries to Tuvalu in recent years.

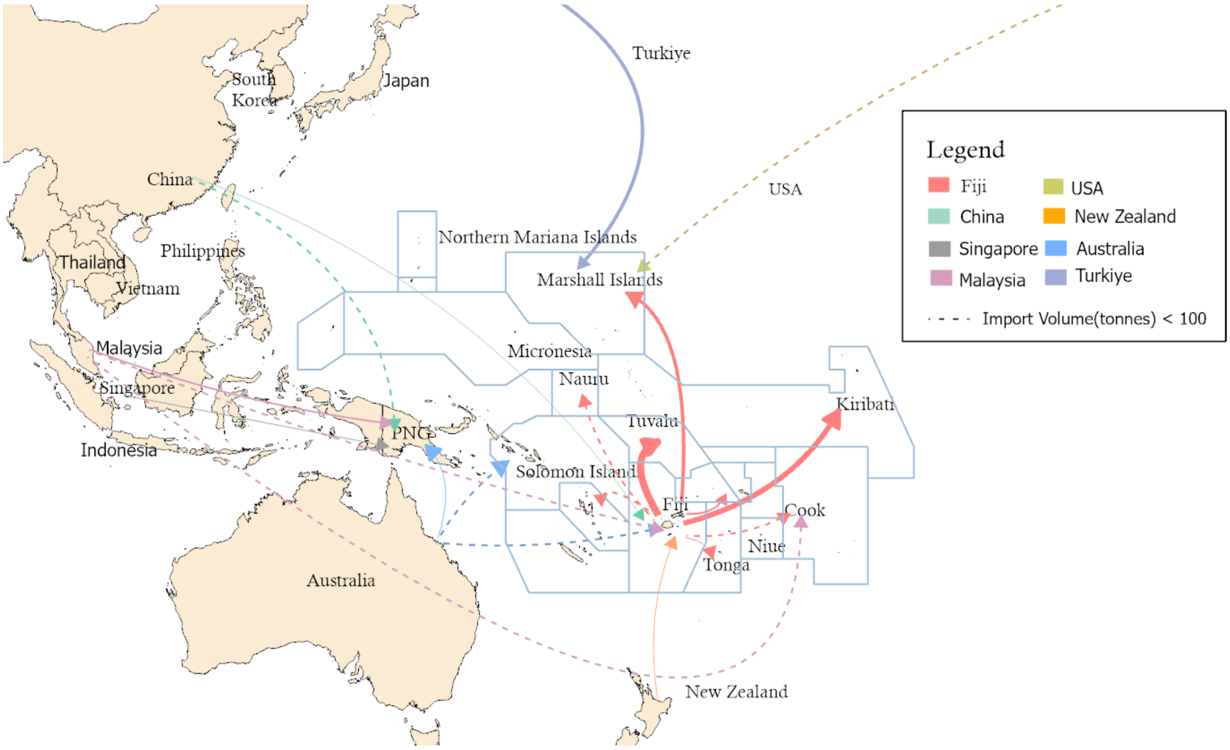
A fourth company, Aggregate Solutions Ltd, based in Ba near Lautoka, has recently started exporting aggregate to Kiribati. The company operates one river gravel operation and, in addition to quarrying, is involved in construction and supply of concrete. It is not known how much aggregate it is exporting.

Suppliers from outside the region

Suppliers from countries outside of the region also play an important role in the Pacific Islands’ aggregate supply. This can be seen in the aggregates supply chain map shown in PNG = Papua New Guinea, . This map covers the 3-year period between 2020 and 2022, with Fiji standing out as the major supplier but with shipments also coming from as far away as Türkiye, and even very small quantities from countries in Europe (not mapped).

[425] *Fiji Sun* (2023. Gold Rock Paves the Way. 16 November. https://fijisun.com.fj/tag/gold-rock-investments-limited/.

Figure 88: Destination and Origins of Aggregates in PICs, 2020–2022



PNG = Papua New Guinea, PRC = People's Republic of China.

Source: compiled from UN Comtrade data

While key exporting countries are known from available trade data, information about the main supplier companies is patchy at best. PRC companies are well-known operators in the region and are major competitors for Australian, New Zealand, and Japanese contractors such as Downer, Reeves Envico, Hall Pacific, McConell Dowell, Kitano and others. They include major PRC state-owned / partially state-owned companies such as China Railway No. 5 Engineering Group, China Railway No. 14, China Harbour Engineering Company, and China Civil Engineering and Construction Corporation, which source aggregate for their projects locally but may also ship directly from the PRC or other countries outside of the Pacific Islands region. These companies have sometimes experienced difficulties in importing aggregate with one often reported story of a company trying to unload aggregates in the RMI for an infrastructure project but being rejected by local authorities due to quarantine concerns. There are no data on the quantities of aggregate that these particular companies ship to the Pacific Islands from outside the region, but it is likely they account for a significant proportion of the trade coming from the PRC each year.

4.2 Transportation and logistics

Shipping companies and routes

There are two main ways in which aggregates are shipped in the Pacific Islands region. The first is via chartered barges which carry bulk cargo with the key companies being Cruz Holdings and Gold Rock both of which are Fiji-based. Hall Contracting also reportedly runs three barges out of Fiji, which have recently been servicing Tuvalu. The second is by scheduled ships that transport aggregates in containers. The main scheduled shipping companies include Neptune Pacific Direct Line, Matson, and Swire Shipping.

Fiji-based Cruz holdings, which is owned by the same company that owns Douglas Concrete, has two barges, both of which have 600-ton capacity. Cruz runs regular charters from Fiji, with recent large shipments to other parts of the Fiji Islands, Tonga, Tuvalu, and Niue. Between 2020 and 2023, this included 18,000 tons of aggregate for sealing chip, road base, and other purposes. Two of its shipments for 1,000 tons each contained both aggregates and cement, though it is not known how much of this was concrete. Gold Rock owns a 6,000-ton barge which is used to ship aggregate from its river operations to other regions and countries, as requested by clients.

Figure 89: Barge Carrying Aggregate off Suva

Photo credit: Robert Smith, 2022

Neptune Pacific Direct Line is headquartered in Los Angeles and is owned by The Wonderful Company, the same company that owns Fiji Water.[426] Neptune provides liner shipping and supply chain services to and from 16 countries in the South Pacific, including services from Asia, Australia, and New Zealand. These are regular scheduled routes. Neptune has a 21-day intra-Pacific service that does a loop between Fiji, Tuvalu, Wallis and Fortuna, and Kiribati, before heading back to Fiji (Figure 90). A variety of other scheduled services are offered, including routes between Fiji, Samoa, American Samoa, Tonga, and New Zealand. All shipments are containerized.

[426] See The Wonderful Company at https://www.wonderful.com/.

Figure 90: Neptune Pacific's Shipping Routes within the South Pacific

Source: https://www.npdlship.com/services/intrapac/

Matsun is an American shipping line based in Hawaii that operates throughout the North and South Pacific with a fleet of 14 container ships. North Pacific operations include regular routes between Okinawa and Guam and Hawaii and Guam, with onward shipping to the RMI and FSM. South Pacific operations now cover New Zealand and Australia to Tonga, Fiji, Samoa, American Samoa, the Cook Islands, Niue, and Nauru, with aggregate shipments possible from Fiji to these other PICs (Figure 91.

The fourth company, Swire, is a large Singapore-based merchant shipping company, established 150 years ago as the China Navigation Company. Swire operates 12 liner services connecting over 400 ports in 90 countries in the Asia-Pacific region and globally. Its services connect Africa, Asia, the Middle East, and US with Guam and Saipan; New Zealand and the islands of the eastern Pacific; East Asia and the southwest Pacific (PNG, Solomon Islands, New Zealand, New Caledonia; North Asia and the Pacific Islands; and the US west coast and Pacific Islands.[427] A new entrant to the shipping market is MSC, though details about its operations in the Pacific are not clear at the present time.

Several contractors and shipping industry representatives stated that shipping costs are "very high" and can comprise around half of the cost of supplying aggregate to other PICs. These high costs are due to ships typically only delivering one-way and returning empty because many countries have limited exports required by other countries in the region.

[427] Swire. https://www.swireshipping.com/information/info-pages/our-solutions/ocean-services/ets/

Figure 91: Matson's Shipping Routes in the South Pacific

Source: https://www.matson.com

Shipping challenges

Lack of suitable, deep-water port facilities, particularly in the atoll countries, means there are limits to the size of ships able to unload in some countries. Vessels are sometimes forced to moor offshore, which can present hazards in rough seas and stormy conditions. The last few years have seen several barges running aground, including two in Nukulaelae in Tuvalu, which were delivering materials for the Tuvalu Outer Island Maritime Transport Infrastructure Project, being funded by ADB.[428] Barging can also be a problem if loading and landing facilities are difficult which, as discussed below, is a challenge Nauru needs to address if it is to increase aggregate exports to the rest of the region.

Very strong ocean currents in parts of the Pacific also present difficulties. According to one infrastructure developer, shipping aggregate south from Nauru is especially difficult and requires larger, more powerful vessels.

Some Australian contractors are apparently restricted by company policy to using only certain carriers due to the need to comply with Australian safety standards. These carriers are reportedly hard to find and, in some cases, have required contractors to source aggregates from Australia and New Zealand, rather than from Fiji or other countries inside or outside of the region.

4.3 Cost considerations

Aggregate costs

The cost of aggregates varies significantly depending on the country, type, quality, and amount of aggregate to be purchased, market conditions, and even the specific quarry it is from. In addition, transportation costs feature significantly in the final price buyers end up paying with remote locations far from the source incurring higher costs.

Each quarry company will have their own aggregate prices, but a general picture can be gained by looking at the prices offered by one of the main exporting quarry companies in Fiji in 2023. As shown in Table 46, AP-grade aggregate, commonly used as base course in driveways and pavement is between F$65–70 (~$29–31) per cubic meter, while for sealing chip (used in roads) prices range from

[428] Asian Development Bank (2019). *Tuvalu: Outer Island Maritime Transport Infrastructure Project, Environmental and Social Monitoring Report*. https://www.adb.org/sites/default/files/project-documents/48484/48484-002-esmr-en_1.pdf. Accessed 28/11/2023.

F$140–170 (~$63–76).[429] Interestingly, limestone was the most expensive quarried material at the time of data collection, reaching F$320 (~$144) per cubic meter, which is perhaps explained by its high demand in agriculture, the cement industry, and other industrial applications.

Table 46: Aggregate Prices of One of Fiji's Main Aggregate Producers and Exporters

Type	Price range (F$/m^3)	Price range ($/m3)
AP20-65 rock[430]	$65–70	$29–31
Sealing chip grades 2-7	$140–170	$63–76
Limestone	$280–320	$126–144
Handpicked spalls (river rock)	$100	$45
Large hard rocks	Each $100	$45
Boulders – various sizes	$65	$29

Source: Unpublished Quarry Price List, Fiji

A desktop review of coastal protection in the Pacific Islands in 2017 determined the following costs to acquire "local materials" for protection works per cubic meter: aggregate/underlayer was $57, sand (~$36), and armor rock ~$115.[431] These costs included supply and placement on site.

Transportation costs

Transportation costs are a major part of aggregate costs used in infrastructure development in the Pacific, particularly in remote locations. Road transportation is usually not a major factor since distances between source and use within countries are typically between 50–100 km. One study reported that road costs range from between A$0.50 to A$1 ($0.38 to $0.77) m^3/km. Shipping costs are considerably higher.[432] The following examples illustrate typical costs:

Scheduled container shipping from primary port: Aggregate is transported 3,000 km and then unloaded locally and transported to site. Typical freight costs would be A$500/m^3 (~$385/m^3) including taxes and import duties.

Remote location from primary port by barge: Aggregate is loaded at a primary port but is to be shipped 2,000 km to a remote location like Tuvalu, which requires chartering a barge. On arrival, the shipment is unloaded at a wharf, jetty or directly onto land using a ramp. Based on typical barge rates, shipping costs would be A$1,000 /m^3 (~$770/m^3). To illustrate the costs involved, a recent aggregate shipment by barge from Fiji to a neighboring country was A$300,000 ($198,676).[433]

4.4 Quality considerations

A major challenge facing infrastructure developers in the Pacific is ensuring the timely and cost-effective supply the right kind of aggregate of an appropriate quality for projects. Not all types of aggregate are suitable for every application. The three main types of aggregate material found in the

[429] Based on a conversion rate of F$1 = $0.45 as of 13/03/2024.

[430] AP20 refers to crushed aggregate sized 0–20mm; AP40 is crushed aggregate up to 40mm and so on. These crushed aggregates are typically used as basecourses for driveways, pavements, etc.

[431] Pacific Regional Infrastructure Facility (2017). *Affordable Coastal Protection in the Pacific Islands: Desktop Review*. https://www.theprif.org/document/regional-guidance-prif/coastal-protection/affordable-coastal-protection-pacific-islands. Values converted from Australian dollars using an average 2017 rate of A$1 = $0.77.

[432] Scheduled shipping container ships only run between major ports, unlike chartered barges. These ships typically transport 18–20 tons of aggregate, which translates into about 33 m3.

[433] Personal communication with Fiji-based freight company. Dated 29 November 2023.

Pacific Islands, i.e., coral aggregate derived from either live or dead coral and lagoon sediments (including sand); uplifted limestone (known as coronus material); and volcanic aggregate (e.g., igneous rocks like basalt) are typically used for different applications. Limestone, for example, one of the most common aggregates used in the Pacific Islands, is a versatile rock that once crushed is suitable for road base, concrete, and other applications.[434] Aggregate made from volcanic rock such as basalt, which is typically much harder, is used to make structural concrete and pavement for high volume roads, while coral aggregates are commonly used as base / sub-base for low volume and unsealed roads and, where no other materials exist, for concrete, though strength is typically lower than concretes made with limestone and hard rock.

There is considerable variation in the properties of these aggregate materials, even within the same type. For example, in the case of uplifted limestone, factors such as the type of the original coral from which the rock was formed, degree of recrystallization, amount of self-cementation and level of contamination by plastic fines, all determine strength and durability.[435] Tonga's quarries, mentioned earlier in this section, are a good example of this. Such rock is sometimes washed after crushing on site to remove fines, which can include materials like clay, silt, and saline that may also be present in coral aggregates and volcanic rock, including river gravel. This can pose a significant challenge in atoll contexts, which are water-constrained due to limited groundwater, and where coral and sand aggregates are the only resources available. Volcanic rock, sourced from hard rock quarries or rivers, is likewise characterized by different strengths and properties, with some contractors describing hard rock from some quarries in Fiji as being of poor quality, while others are described as "excellent rock". This, coupled with river sand (and uncrushed gravel) that tends to be more rounded, rather than the preferred angular shape, explains why some quarries in countries like Fiji mix different rock types on site to produce aggregate with desired properties. There is also significant variation in the strength and suitability of marine sediments dredged from lagoons, with foraminiferal sediments being better suited to the strength requirements of certain concretes, such as those exposed to marine environments, which require strengths as high as 50 megapascals.

The gold standard for ensuring aggregate meets quality specifications is to undertake testing in certified laboratories with trained staff. A variety of tests may be conducted, including strength tests (e.g., California Bearing Ratio), crushing tests, abrasion tests, shape tests, specific gravity and water absorption tests, and so on.[436] Discussions with donors and industry stakeholders in several countries revealed challenges with accessing labs or with labs that do not have the right equipment and staff with the necessary training on how to undertake testing. For instance, one donor representative in Vanuatu reported that there is only one lab capable of testing aggregate, but it is staffed by people with no training or qualifications in materials engineering.[437] In this case, contractors therefore rely on an overseas advisor who would periodically come to test materials.

Similarly, in Solomon Islands, there is only one operational lab, which is sometimes overwhelmed with the volume of work (tests) it can perform based on the available projects and is currently not accredited. Here, the main problem is that the fluctuations in infrastructure activity, and hence aggregate demand, mean that labs do not have consistent income to ensure equipment is maintained, they may lose accreditation, e.g., with National Association of Testing Authorities in Australia and skilled staff may leave.[438] The Solomon Islands Ministry of Infrastructure Development stated that

[434] Pacific Regional Infrastructure Facility (2016). Road Pavement Design for the Pacific Region: Desktop Research of the Use of Local Materials. https://www.theprif.org/document/regional/transport/road-pavement-design-pacific-region#:~:text=The%20study%20investigated%20options%20to,of%20road%20construction%20and%20maintenance

[435] Bullen, F. and Williams, D. (1988). Coralline Calcareous Pavement and Foundation Aggregate. In A. Jewell (Ed.), *Engineering for Calcareous Sediments Volume 1*. CRC Press, London, UK.

[436] https://civilblog.org/2015/09/12/7-lab-tests-on-aggregate-to-check-quality-for-use-in-road-work/

[437] Personal communication with donor representative in Vanuatu. Dated 24 August 2023.

[438] Personal communication with representative of Solomon Islands Ministry of Infrastructure Development. Dated 27/08/2023.

there is also a major challenge recruiting qualified operating staff for the laboratory. Upgrading, accrediting, and operating labs is also very expensive with one recent estimate for a lab in Solomon Islands reaching SI$8,261,100 (~$975,000) over a 3-year period.

Even in Fiji, contractors have had difficulties in getting some aggregates tested. Although there are currently several laboratories operating in Fiji, including four owned by Fijian engineering and science consulting firm Entec, not all are able to perform all the tests needed. In one case, it was reported that aggregates had to be sent to Australia because access to labs capable of conducting abrasion and sand plasticity tests was not possible.

Despite the generally lower quality and strength of coral aggregates, there are reports of successful outcomes for construction of roads, causeways, and even seawalls dating back to the Second World War. For instance, the US Army Corps of Engineers built roads and causeways in the RMI that were impressive in their quality and resilience.[439] Recent fieldwork in the RMI undertaken as part of this study also revealed that a major seawall in Majuro, built by the Japanese using coral rubble in 1940, is still standing and apparently in good condition (Figure 46).

One explanation for the quality of such infrastructure is the technique used. One donor representative explained that the US Army had "perfected the science of controlled drying of coronus material so that it sets like concrete". This has to do with the chemical reaction between water and the calcium carbonate. Such techniques are certainly worth exploring today, particularly in resource limited atoll countries and regions. However, the environmental cost of using coral materials on a large scale during the war years was often extreme and strict safeguards would need to be put in place if this approach is to be tried today.

Table 47: Seawall in Ebey, the RMI, Built from Local Coral Rubble by the Japanese circa 1940

Photo credit: Gary Lee, SPC November 2023

A related point is that some infrastructure developers / donors are of the view that more can be done to engineer local materials so that they are fit for purpose. The causeways and roads built using local coral rubble and limestone during the Second World War illustrate this well. Yet good engineering techniques can be as simple as contractors working with local quarry operations to crush and mix aggregate coronus (limestone) material in a way that produces aggregates of the required quality and size for a particular application, such as for road base or concrete. Much more needs to be done in this area if aggregate challenges in the Pacific are to be overcome.

A final point affecting the quality of materials available to projects is the influence of local rent seekers in government or other organizations who, in some countries, have been known to push projects to

[439] Personal communication with infrastructure developer / DFAT representative. Dated 21/10/2024.

source from quarries where they have a vested interest, but which have poor quality materials. Meanwhile, quarries with better quality materials are overlooked.

4.5 Potential alternative sources of aggregate within the region

There are several potentially significant sources of aggregate within the Pacific Islands region that have not yet been fully utilized or explored yet could be with the right policies and support. These are discussed in the sections below.

Nauru

Nauru, once renowned for its phosphate mining, has large reserves of limestone dolomite, an anhydrous carbonate mineral that can be crushed to produce strong, high-quality aggregate suitable for concrete and other applications. Data on current production of dolomite were not available at the time of writing but it has been estimated that Nauru's primary and secondary pinnacles comprise around 30.5 million m^3 of rock.[440] This dolomite is a waste product resulting from decades of phosphate mining and its extraction would have the benefits of creating a valuable product and rehabilitating disturbed land, which is scattered with dolomite pinnacles (Figure 92). The Government of Nauru, through NRC, is currently quarrying dolomite for armor rock and aggregate, primarily for its port redevelopment and to meet domestic construction demand,[441] including 25,000 tons for the airport upgrade.[442] Between 2009 and 2015, Nauru exported total of 55,820 tons of crushed rock and armor rock to Pacific International Inc. in Majuro in the RMI and the government plans to recommence exports to the RMI and other Pacific atoll countries such as Kiribati and Tuvalu.

Given the significant adverse environmental impacts of intense phosphate mining on Nauru in the past, an expanded dolomite export industry may not be welcomed by all stakeholders. It is therefore important that the NRC obtains a social license to expand operations via meaningful stakeholder engagement with the public. Engagement with infrastructure donors should also be undertaken. It will be essential to establish key sustainability parameters for dolomite extraction so that operations complement rehabilitation efforts, rather than create new problems.

Following this, studies will be required to fully assess the market potential and, assuming the findings are favorable, a suitably sized barge to transport the aggregate will need to be purchased to make deliveries competitive. At present, delivery to Kiribati and Tuvalu is a major barrier due to the lack of regular shipping and unsuitable port facilities, which require onloading and offloading cargo offshore.[443] Nevertheless, NRC has already delivered shipments using Vanuatu-based Ocean Logistics to both the RMI and Tuvalu at $45/ton (where 5,000 tons were purchased).[444] Customers are obliged to arrange and pay for a barge to transport the aggregate. Increasing this export business is a key pillar of NRC's business strategy going forward.

[440] Davis, J.W. (2010). *The Feasibility of a Nauruan Limestone Industry and its Linkage with Rehabilitation*. Boulder: The Environmental Studies Institute.

[441] Minister for Finance of the Republic of Nauru (2020). Republic of Nauru Budget Paper No. 2 2020–2021. https://naurufinance.info/wp-content/uploads/2020/07/BP-2-2020-21-Final-20200603.pdf. Accessed 01/12/2023.

[442] Personal communication with infrastructure contractor. Dated 30/10/2023.

[443] Nauru Rehabilitation Corporation Corporate Plan, 2019–2025; Asian Development Bank (2020). *How Innovation is Helping to Deliver a New Port for Nauru*. https://www.adb.org/results/how-innovation-helping-deliver-new-port-nauru#:~:text=Funding%20for%20Nauru's%20new%20port,keep%20the%20project%20on%20track. Accessed 01/11/2023.

[444] Radio New Zealand (2017). Tuvalu Buys 5000 Tons of Rock from Nauru. 22 September. https://www.rnz.co.nz/international/pacific-news/339973/tuvalu-buys-5000-tons-of-rock-from-nauru; NRC was reportedly asking the RMI buyer for $50/ton but this was rejected.

Other challenges will need to be overcome if Nauru is to become a major exporter of aggregate. One donor representative stated that while Nauru has good quality crushing equipment provided by Australia, the port facilities do not include a ramp to unload aggregate from trucks onto barges. However, engineering reports indicate that such a ramp will be included as part of the port redevelopment, which was designed by Cardno and being built by China Harbour.[445] Management of quarry operations is also allegedly not up to standard, which is apparently impeding production. Another source claimed that like roads, access points, and benching (essential to run a safe operation), are often neglected.[446] Quarrying is also affected by skills shortages, such as trained blasting engineers, a problem also reported in other countries such as Tonga.

Figure 92: Dolomite pinnacles in Nauru

Photo credit: Peter Ollivier 2019

New Caledonia

The second source is SLN's vast stockpile of ferro-nickel slag in New Caledonia, known as "Le Sland" (Figure 93). The slag is a by-product of nickel processing that can be used as a supplementary cementitious material in cement and can also be ground into a manufactured sand that can be used as an aggregate. SLN is a subsidiary of French mining company Eramet. Discussions with the company indicate that there are currently 25 million tons of Le Sland stockpiled in New Caledonia and around a million tons are added each year. Le Sland has been used in New Caledonia for land reclamation, road base, concrete blocks, tetrapods, and Seabee units for coastal protection, and other purposes for over 20 years. In 2018, SLN started exporting to other Pacific Island nations including Vanuatu, where Le Sland was used for soil stabilization and filling geotextile bags for coastal protection. It has also been used to make concrete blocks for housing in Tonga. In 2019, 10,000 tons were also

[445] Government of Nauru (2017). Nauru: Sustainable and Climate Resilient Connectivity Project (48480-002) – Project Design Advance (PDA) - UXO Clearance, Geotechnical Investigations, Surveys and Detailed Engineering Services.
[446] Personal communication, infrastructure contractor. Dated 30/10/2023.

exported to New South Wales in Australia for trial purposes where it was being tested in concrete mixes blended with crusher dust.

SLN has stated that it is not seeking a profit from Le Sland and that the indicative free-on-board price for putting Le Sland on a barge is $5/ton, while shipping costs to Vanuatu would be an additional $18/ton and $14/ton to Tonga. Despite this, uptake in the Pacific Islands is slow. Several contractors stated that they had been looking into the use of Le Sland in various projects but that the idea had been abandoned, though the reasons were not clear.

Further testing and engagement with users and standards bodies in the Pacific will be needed to build confidence in Le Sland so that its full range of properties and suitability for infrastructure applications is better understood.

Figure 93: Left – Aerial view of SLN site and stockpile in New Caledonia photo: Google Earth; Right - Le Sland stockpile

Photo: SLN

Ore sands from mining operations in Fiji and other countries

A longer-term option for countries might be to produce ore-sand by-products from silicate-rich metal ores for both domestic and export markets. Ore sand is a relatively new innovation that adds new processing circuits to create an additional product to the primary mineral being mined.[447] Ore sand has numerous applications, including as construction aggregate and other industries (e.g., silica sand).

The ore sand approach offers significant benefits, including reducing the volume of mining waste, reducing the extraction of sand from the natural environment, with resources already over-extracted globally, and creating a valuable product. Global mining giant Vale has already begun commercially producing and selling ore sand at some of its operations in Brazil and there is potential for existing mining operations in Fiji, PNG, and Solomon Islands to do the same,

[447] Golev, A., Gallagher, L., Vander Velpen, A., Lynggaard, J.R., Friot, D., Stringer, M., Chuah, S., Arbelaez-Ruiz, D., Mazzinghy, D., Moura, L., Peduzzi, P., Franks, D.M. (2022). Ore-sand: A Potential New Solution to the Mine Tailings and Global Sand Sustainability Crises. Final Report. Version 1.4 (March 2022); Segura-Salazar, J. and Franks, D.M. (2023). *Ore-sand Co-production from Newcrest's Cadia East HydroFloat Reject: An Exploratory Study*. The University of Queensland; Valenta, R.K. et al. (2023). Decarbonisation to Drive Dramatic Increase in Mining Waste–Options for Reduction. *Resources, Conservation and Recycling*, 190: 106859.

provided the economic and technical analysis is favorable. One newly operating gold mine in Fiji has already expressed interest in exploring the production of ore sands,[448] while discussions are being held with other companies in Fiji and beyond.

Other potential sources of aggregate

Several other PICs have potential to be net exporters of aggregate. As the third-largest island country in the world with diverse geology, PNG has significant potential to export all aggregate types to neighboring countries, such as nearby Palau and Solomon Islands. PNG may also be the best place for river extraction given the sheer number and size of its rivers and their ability to naturally recharge. To date, however, the quarry sector has been focused on supplying materials for the domestic mining and oil and gas industries and construction sector, with only very small quantities of aggregate exported during 2018–2022.[449] Currently, much more aggregate is imported to PNG than it exports. If PNG is to become a net exporter to the region, significant industry engagement will be needed to understand the barriers and market drivers for aggregate production and export, as well as information on the location, type, and quality of aggregates available.

As discussed in the country profiles, Samoa reportedly has excellent sources of basalt, which are not yet being fully exploited, as well as sand resources. Much of the rock extracted at the present time is being used for the improvement of Apia Port, being funded by ADB (Figure 94). To date, exports have been infrequent, though one industry source reported that 30,000 tons of rock was to be shipped to Tokelau via multiple trips on 2,000-ton barges. However, one donor representative was of the opinion that, while Samoa has excellent rock, its role as a regional supplier is limited given the small size of the country, relative to countries like Fiji, and the likely environmental footprint of establishing a large aggregate export sector.

Figure 94: Large Basalt Boulders from Quarry in Samoa Supplying the Apia Port Project

Photo: Daniel Franks, 2023

Banaba Island, Kiribati

As with Nauru, there is potential to quarry limestone / dolomite on Banaba Island, a raised limestone island in the Gilbert Islands of Kiribati, some 300 km east of Nauru but many challenges lie in the way. Similar to Nauru, Banaba (also known as Ocean Island) was the site of extensive phosphate mining during the 20th century, which has left the landscape littered with dolomite pinnacles. It also resulted in the displacement of most of the island's population, who were resettled in the north of Fiji on Rabi Island after the Second World War. Although a small population remains, commencement of dolomite mining will have to be approached carefully given

[448] Discussion with Lion One at the Science and Technology Resources Conference on Risks of Infrastructure Development in the Pacific 2023 Suva 20–24 November.

[449] UN Comtrade database. Accessed 30/10/2023.

recent opposition by some of the displaced population to plans by Australian company, Centrex, to resume phosphate mining on the island.[450]

However, consultations with officials in Kiribati indicate that there is interest among Banabans to develop an aggregate industry on the island. Furthermore, if dolomite mining were to contribute to the rehabilitation of Banaba's degraded landscape and generate economic opportunities, Banaba's former and current inhabitants may be particularly supportive of opportunities in this area. As such, it may be worthwhile engaging with Banabans to determine their openness to the idea, one which should clearly be differentiated from a resumption of phosphate mining, bearing in mind that current proposals are to mine both secondary phosphate and limestone.

Other more practical barriers would also have to be addressed. One includes the lack of suitable landing and shipping facilities, while another includes the lack of heavy equipment on island necessary for breaking up the limestone and transporting and loading aggregates on ships. Roads will also have to be cleared to enable access to mined areas where there is limestone.

5. Environmental, Social, Occupational Health and Safety, and Economic Analysis

5.1 Environmental and social impacts of aggregate extraction

Aggregates, including sand, gravel, and rock, provide important ecosystem functions and services by maintaining biodiversity[451] and supporting hydrological systems, as well as contributing to economic development and the livelihood of the nearby communities. Despite their ecological and economic importance, the extraction and sourcing of aggregates is not monitored and managed adequately in many regions of the world, resulting in significant environmental and social impacts.[452] This is particularly evident for the PICs, where addressing the consequences associated with aggregate extraction represents a serious governance challenge due to the lack of financial resources and technical expertise.

[450] INDAILY (2023). SA Miner's Pacific Plans 'On Hold' as Islanders Fight Back. 5 September. https://indaily.com.au/news/business/2023/09/05/sa-miners-pacific-phosphate-plans-on-hold-as-banabans-fight-back/.

[451] Aggregates (rock and sand) have strong links with biodiversity. For example, bare rocks or rocky slopes provide habitat for different types of species and communities (e.g., nesting habitat for birds, insects, plants like lichens, coral reefs). Rock (sand or gravel) may also influence water chemistry. The aquatic biodiversity of lakes or rivers reflect the derived water chemistry, with species being adapted to different pH regimes, as well as light penetration. They also play a vital role in protecting coastal communities (mangroves) from sea-level rise.

[452] United Nations Environment Programme (2022). Sand and Sustainability: 10 Strategic Recommendations to Avert a Crisis. Geneva: UNEP. https://www.unep.org/resources/report/sand-and-sustainability-10-strategic-recommendations-avert-crisis. Accessed 29/11/2023; Padmalal, D. and Maya, K. (2014). *Sand Mining: Environmental Impacts and Selected Case Studies*. Springer; United Nations Environment Programme (2019). Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources. https://wedocs.unep.org/20.500.11822/28163 . Accessed 29/11/2023.

In the Pacific, aggregate extraction is mostly being carried out by small to medium-sized formal and informal companies and in some cases for individual purpose in the form of beach-sand mining. This section discusses the current knowledge on the impacts of river gravel extraction, hard rock quarrying and sand dredging (in atoll settings), as well as the effectiveness of the current legal frameworks and "best practice" guidelines in place to mitigate the impacts of aggregate extraction. A selection of countries representing the different types of aggregate resources and extraction methods are used to illustrate key issues and challenges.

The section begins by looking at the impacts of river gravel extraction activities in Fiji and Solomon Islands, followed by a discussion on the impacts of limestone quarrying and groundwater vulnerability in Tonga. Next, it analyzes the impacts of phosphate mining on Nauru's natural environment and the possibility of utilizing the dolomite resources while taking into consideration the need and efforts for rehabilitation of the island's natural environment. The final part looks at the state of sand and coral dredging in the atoll countries including Kiribati, Tuvalu, and the RMI.

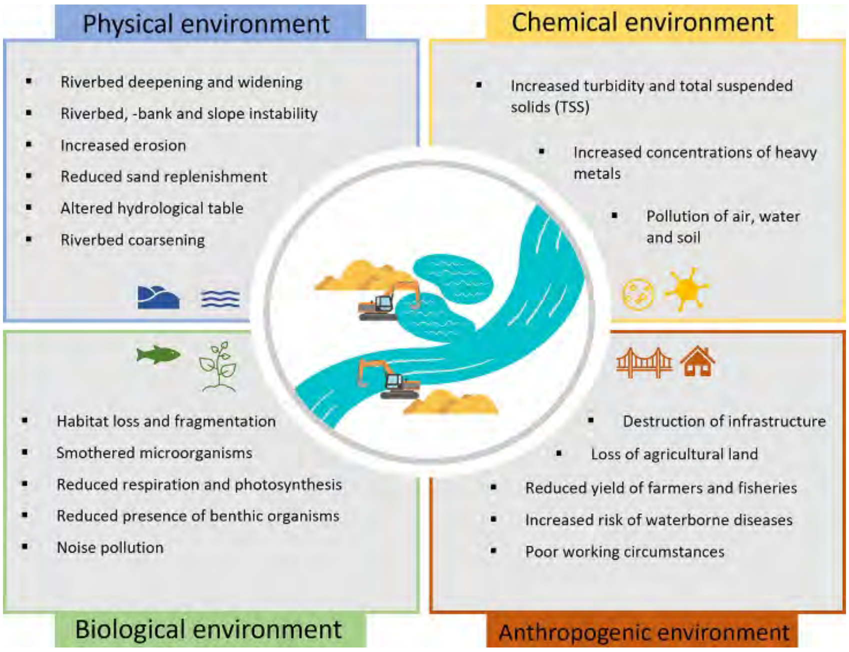
5.1.1 The impacts of river gravel extraction in Fiji and Solomon Islands

River extraction activities impact river systems by altering the physical and chemical environment and consequently impacting the biological and anthropogenic surrounding environment[453] (Figure 95). The effects of river sand and gravel mining on the physical and chemical environment are hard to quantify and require routine measuring and comprehensive baseline data. However, the observed effects are widespread and cumulative, resulting in decreased biodiversity and in harm to the livelihoods of surrounding communities through loss of fishing grounds, flooding, and clean water availability.

Sustainable river extraction requires mapping out these activities and conducting thorough baseline assessments that include water quality testing, river profile and hydrological studies, resource estimations and natural replenishment rates, biodiversity, and social impact assessments. Continued monitoring should also be enforced by the relevant regulating bodies to ensure compliance with the environmental and social conditions.

[453] Rentier, E.S. and Cammeraat, L.H. (2022). The Environmental Impacts of River Sand Mining. *Science of the Total Environment*, 838: 155877.

Figure 95: The Environmental Impacts of River Sand Mining



Source: Science of the Total Environment

Fiji

The 2018 Baseline Assessment of Development Minerals in Fiji evaluated the impacts of river gravel extraction through direct observations and community surveys.[454] Approximately 46 (76%) of Fiji's gravel and sand extraction operations were located in its rivers. However, based on the 58 EIAs studied for the baseline, the authors concluded that the cumulative and downstream impacts of river extraction activities are not carefully considered. It was also estimated that there were at least 30 unregulated sites, which would mean they have few or no environmental and social impact management measures in place.

In many cases, operators were also observed to extract material directly from the river channel with no sediment control measures such as silt fences (Figure 96). This can result in increased sedimentation and siltation in the extraction site and further downstream. However, caution needs to be exercised in making definitive conclusions about the cause of sedimentation / siltation given it can be the result of high levels of rainfall, deforestation, or other activities, as opposed to river extraction. For instance, analysis of satellite imagery should be undertaken alongside analysis of local rainfall data to determine if heavy rainfall or extraction is the cause of sedimentation and siltation.

Due to low seismic- and earthquake-induced erosion, the lack of glaciers and freeze-thaw erosion, and a warm climate that supports high rates of chemical weathering, Fiji is less likely to generate gravel during erosional events. As a result, river gravel and sand extraction rates are likely to surpass natural river replenishment rates in many cases. For example, Figure 97 shows geo-referenced imagery of the Navua River from 1951 to 2017, which demonstrates a significant decrease in the measured gravel bar area throughout the years.[455] Between 1997 (pre-mining) and 2010 (post-mining) there was a decrease of about 62% in the gravel bar area, suggesting that river gravel mining was exceeding bedload replenishment rates.

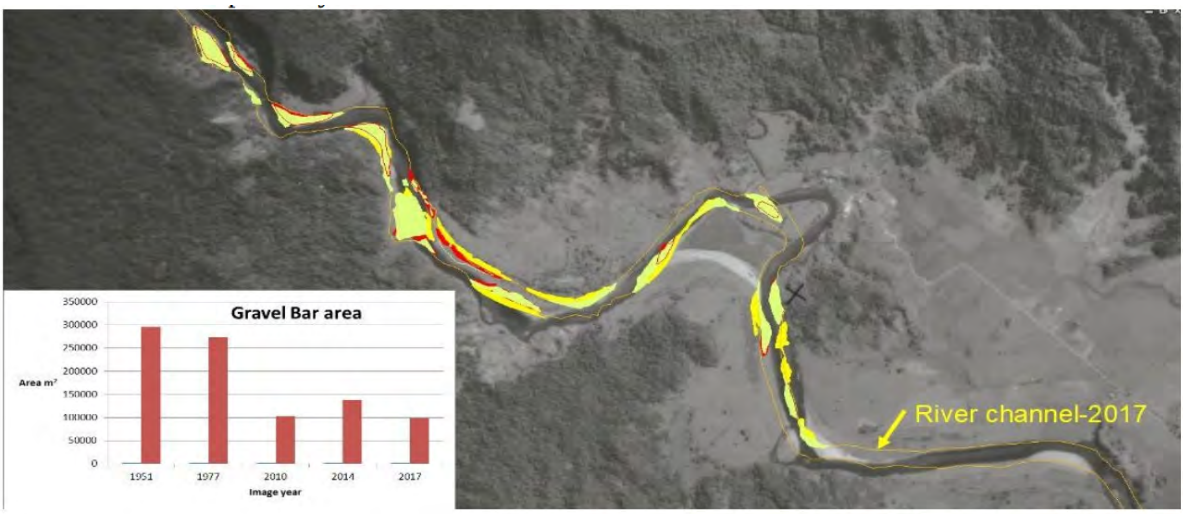
[454] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme.

[455] Taga, R. & Smith, R. (2021). *A River Gravel and Sand Extraction Guideline 2021*. Compiled by Dr Raijeli Taga and Robert Smith. Fiji Ministry of Lands and Mineral Resources. Development Minerals Technical Working Committee. In review.

Figure 96: River gravel extraction site in Fiji where aggregate is extracted for major infrastructure projects. Photos show A) operation phase and B) the post-mining impacts such as altered riverbed hydrology and increased suspended sediment.

Photo credit: Daniel Franks, 2022

Figure 97. Satellite imagery showing the changes in gravel bar area from 1951 to 2017 in the Navua River, indicating that mining is outstripping bedload replenishment rates.



Source: Taga and Smith 2001 - A River Gravel and Sand Extraction Guideline

The pollution and changes in the river hydrology from multiple extraction activities often result in cumulative impacts in the biological and anthropogenic environment. A simple spatial analysis was conducted to measure the distance of river gravel extraction sites in Fiji with downstream marine protected areas and illustrate the potential cumulative impacts of multiple operations along the same river system or catchment (Figure 98). Almost half of sites (n=21) are within 27 km from a Protected Area, with approximately 19% being within 10 km. In some instances, there are multiple operations occurring in the same river system, for example, the Navua and Dawasamu rivers in Viti Levu and Lambasa river in Vanua Levu. Approximately 143 species are known to spend half of their adult lives in freshwater, of which 132 are native to Fiji's rivers and at least five are considered endangered.[456]

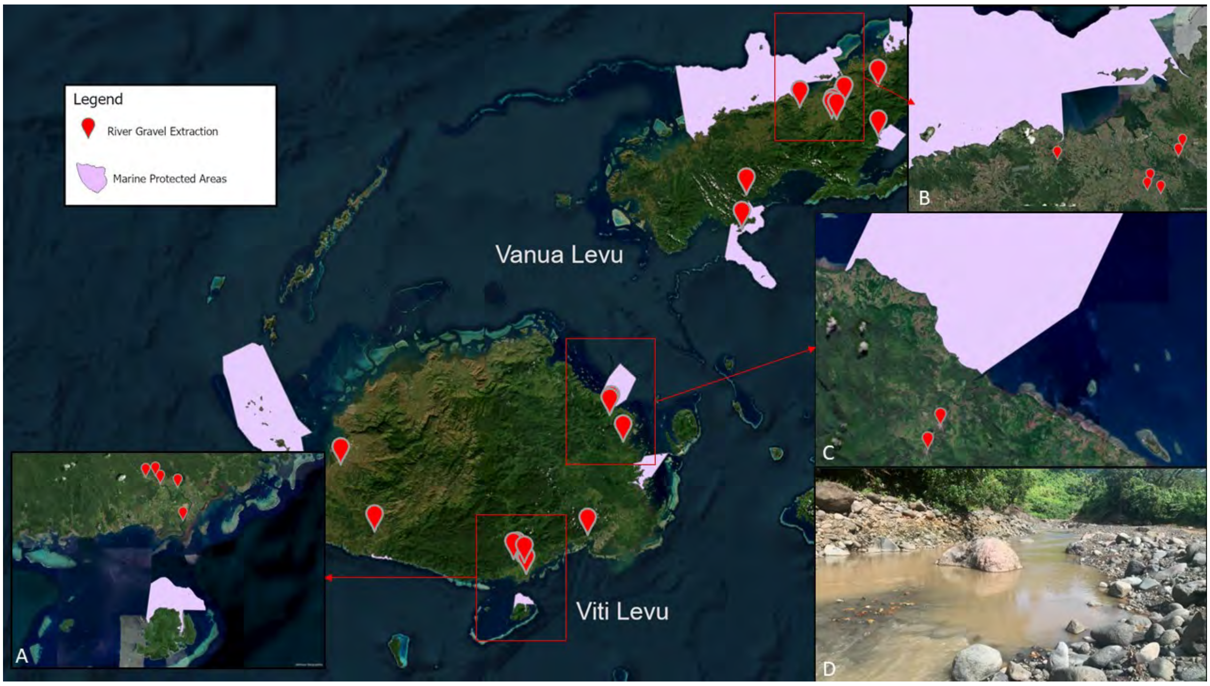
[456] Smith, R. et al. (2018). *Baseline Assessment of Development Minerals in Fiji*. Suva, Fiji: United Nations Development Programme.

This could result in decreased fish abundance and diversity not only where extraction is occurring, but in the coral reefs downstream, thus impacting multiple ecosystems and communities that depend on fish for their sustenance and livelihoods.

Rivers also provide other essential ecosystem services to the communities living in the vicinity of operations and depend on the river water for everyday activities such as transportation, drinking, watering plantations, cooking, bathing, washing household items and providing water to livestock. More than half of the community members surveyed for the baseline assessment reported an increase in health issues associated with the increased water pollution such as skin diseases, ringworms, or typhoid. Approximately one-third of the surveyed individuals surveyed from the communities nearby river extraction sites reported a decline in 11 species following the establishment of the river extraction operations. Concerns were also reported regarding increased health and safety hazards to community members utilizing the river for boat transportation and eco-tourism, including cases of damaged and capsized boats.

Ideally EIAs should include baseline environmental and social studies of the surrounding ecosystems and communities that could be impacted by the operation. This can include river cross-section measurements, bathymetric surveys, on-site photographic records from established benchmark locations, imagery analysis using both satellite and aerial photography and assessments on the cumulative and biodiversity and social impacts. Continued monitoring throughout the operational phase of the extraction activities is also essential to ensure compliance to license conditions.

Figure 98: Satellite imagery showing the spatial proximity between river gravel and sand mining operations in Fiji with marine Protected Areas. Photo shows A) Multiple extraction sites in the Navua River in close proximity to a PA, B) Multiple extraction sites in Labasa River close proximity to a PA, C) Two extraction sites in Dawasamu River close proximity to a PA and D) Increased suspended sediment in the river due to river sand mining in the Dawasamu River.



Source: Produced by authors, 2023 using Google Earth and ArcGIS Pro; photo credit Bora Aska, 2023

Solomon Islands

Based on the EIAs included within the building materials permit (BMP) obtained during the fieldwork in Solomon Islands, the negative environmental and social impacts of river gravel extraction are not carefully considered or assessed. There are 26 BMPs issued to river extraction operators in the Honiara River catchment and one to a beach mining operator in Nughu Island. The application process for acquiring a BMP involves the preparation of an EIA, which includes a description of the operation including planned extraction volumes, EMPs, and health and safety procedures to be implemented during operation. The EMPs for different operations appear to be very similar and general, which suggest operators are using plans developed for other projects and not addressing unique and specific environmental impacts of their projects. Very few EMPs were comprehensive enough to describe the quality of the surrounding environment such as the biodiversity, water and air quality, hydrology and river profile based on literature reviews and general knowledge of the Solomon Islands environment. There were also no site-specific assessments of any of these indicators.

During the field visit to Solomon Islands, environmental conditions surrounding some of the extraction sites in Lunga and Ngalimbiu Rivers were observed to have increased levels of erosion, siltation, and increased suspended sediment levels. When comparing the water quality upstream of the river gravel operations on the Lunga River to that downstream on the same day (Figure 99 and Figure 100), there appears to be a significant increase in water turbidity and suspended sediments, suggesting that the extraction activities might be impacting water quality (Figure 100). Currently, most of the gravel extraction activities occur in the Lunga river. Without comprehensive baseline assessments of the river's hydrology and surrounding environment that can be used for monitoring compliance to permit conditions, the impacts will persist and become more widespread as more river gravel extractions continue to be established in other rivers across the Honiara catchment.

Figure 99: Satellite imagery showing the water quality downstream of the multiple river gravel extraction sites in the Lunga River, Honiara.

Source: Produced by authors using Google Earth imagery, 2023

Figure 100: Satellite imagery showing the water quality upstream of the multiple river gravel extraction sites in the Lunga River, Honiara.

Source: Produced by authors using Google Earth imagery, 2023

5.1.2 The environmental impacts of quarrying

Limestone quarrying and groundwater vulnerability in Tonga

Limestone quarrying is correlated with contamination of groundwater and disrupted groundwater supply, as well as more localized impacts such as land clearing, biodiversity loss and air pollution.[457] Groundwater from aquifers is the main source of drinking water in Tonga.[458] Tongatapu, the Kingdom's main island, is a low-lying island approximately 65 m above sea level. Hence, water quality and availability are highly dependent on the low-lying profile, climate, and other anthropogenic factors.

The most common quarrying practice is to remove and stockpile the topsoil overburden then extract limestone down to the water table, which causes risks to groundwater including contamination and increased evaporation.[459] The Mataki'eua/Tongamai wellfield (the land above and surrounding wells drilled into an aquifer) in Nuku'alofa is of concern due to its vicinity with major quarry operations. There are four quarries within 1.6 km distance from the closest well. The Tapuhia Waste Management Facility is an abandoned quarry, repurposed as a waste management facility. However, groundwater remains exposed at the base of the facility (Figure 101). The water in this site had concentrations of lead 25 times higher than the World Health Organization's

[457] Eyankware, M.O., Akakuru, O.C. (2022). Appraisal of Groundwater to Risk Contamination Near an Abandoned Limestone Quarry Pit in Nkalagu, Nigeria, Using Enrichment Factor and Statistical Approaches. *International Journal of Energy and Water Resources*, 7: 603–621.

[458] Sharan, A., Lal, A., and Datta, B. (2023). Evaluating the Impacts of Climate Change and Water Over-Abstraction on Groundwater Resources in the Pacific Island Country of Tonga. *Groundwater for Sustainable Development*, 20: 100890.

[459] White, I., Falkland, A. and Fatai, T. (2009). Vulnerability of Groundwater in Tongatapu, Kingdom of Tonga: Groundwater Evaluation and Monitoring Assessment. Report to Pacific Islands Applied Geoscience Commission, EU EDF8. https://www.iahr.org/library/infor?pid=25046. Accessed 29/11/2023.

acceptable concentrations for drinking water that predated the use of the site as a waste management facility and high concentrations of nitrates that occurred after the waste facility started operating.

Cases of limestone being excavated down to groundwater and groundwater ponds being exposed to quarry and other industrial or agricultural waste also occur in active quarry operations such as the Malapo (Figure 102) and Kahoua quarries (Figure 103). The lack of groundwater monitoring boreholes across the island indicates it is difficult to determine the flow of the groundwater or the impacts of quarrying on water quality. Further, the observed practices in the aforementioned quarries illustrate significant risk to groundwater quality.

Under Tonga's EIA Act 2003, quarry developments do not require an EIS that details the environmental and social characteristics of the environment. This would include assessment of the maximum depth of limestone extraction for each development as to not intersect with the groundwater surface, assessment of water flow direction and quality and proximity to wells and boreholes. As is the case with other PICs, EIA/EIS are often ineffective due to capacity limitations and lack of continued monitoring that leads to operators failing to comply with regulations and development conditions. Instalment of monitoring boreholes must be mandatory for continuous monitoring and reporting of water level and quality. Rehabilitation is also important for abandoned or existing quarries. For existing quarries, where the water table has been exposed, the ground should be backfilled to a depth of 2 m. In abandoned quarries, techniques to skim off the fresher groundwater from close to the surface using horizontal infiltration galleries at the base of the quarries could be implemented to deliver low salinity water.

Figure 101: Satellite imagery showing an abandoned limestone quarry in Tongatapu, now repurposed as a Waste Management Facility.

Source: Produced by authors using Google Earth imagery, 2023

Figure 102: Satellite imagery showing the Malapo limestone quarry in Tongatapu, which is 1 km distance from a water well.

Source: Produced by authors using Google Earth imagery, 2023

Figure 103: Satellite imagery showing the Kohoua limestone quarry in Tongatapu, which is at 1 km distance from a water well.

Source: Produced by authors using Google Earth imagery, 2023

The implications of dolomite extraction for Nauru's rehabilitation plan

Nauru's phosphate mining had significant impacts on the environment. Approximately 80% of the land on the central plateau of the island was deforested, leading to degradation, erosion, and loss of topsoil (Figure 104). NRC was established in 1999 by the government with the aim to rehabilitate lands impacted by the phosphate industry through soil restoration and revegetation. However, it has been argued the efforts have not given the desired results due to constant government changes, lack of financing and the expiration of the AusAID money that was keeping most of the rehabilitation programs going.[460] Moreover, most of the legislation governing the extraction and management of marine and terrestrial resources and rehabilitation of mined-out lands is outdated and there are no clear government records that these legislations are being monitored and enforced. Thus, rehabilitation remains a challenge for Nauru.[461] Even undisturbed land is shallow, nutrient-poor, dry, and lacking in trace metals and organic content.

Soil fertility and water availability are the main issues hindering reforestation and establishment of an agricultural sector. Nauru has variable rainfall patterns due to high soil permeability and its underlying geology. Groundwater is used to maximum capacity, and Nauru often imports fresh water. Soil and water limitations must be addressed before repurposing the land for other uses.

However, the first step toward rehabilitation would be the levelling of limestone pinnacles to refill the pits from phosphate mining and overlying this substrate with soil. Due to the limitations mentioned above, the current rate of rehabilitation of land per year is around 26 ha, meaning that it would take almost 6 decades to complete the rehabilitation of all land impacted by phosphate mining. While Nauru presents an important opportunity for good-quality construction limestone, it would be beneficial for ADB, World Bank or others to support NRC in making sure extraction and rehabilitation are undertaken together according to good practice.

Figure 104: Aerial view of Nauru showing 80% of vegetation lost due to phosphate mining

(Source: Getty Images)

[460] Ali, S., Clifford, M. and Matsubae, K. (2017). *Mining and Socio-ecological Resilience in Mineral-Rich Small States: An Integrative Approach to Phosphate Mining on Nauru*. SSRN 3009738.

[461] Clifford, M. J., Ali, S. H., & Matsubae, K. (2019). Mining, Land Restoration and Sustainable Development in Isolated Islands: An Industrial Ecology Perspective on Extractive Transitions on Nauru. *Ambio*, 48(4): 397–408. https://www.jstor.org/stable/48693474.

Environmental monitoring in Niue

Niue has two hard rock quarries in close proximity to the capital Alofi, and several smaller borrow-pits close to the main quarries and along the main Hakupu-Liku Island Road. According to the available Google Earth Pro imagery, the quarries have been operating since 2006, with some of the borrow pits becoming active more recently.

Niue's most recent State of Environment Report 2019 does not mention quarrying or mining of aggregates as a major threat to the environment.[462] This suggests that there are no significant environmental impacts related to hard rock quarrying in these sites with the exception of the usual land-clearing activities, noise, and air pollution occurring during operations.

One reason may be the increased ability of relevant government agencies to undertake good practice environmental monitoring. As mentioned in Niue's country profile, the Environment Act 2015 and Regulations 2017 list commercial extraction of aggregates, sand and beach rock as activities that require development consent and must go through the EIA process. Before the Environment Regulations were enacted in 2017, SPREP's Environmental Monitoring and Guidance Division facilitated an EIA training and skills development workshop for government officials.[463] SPREP representatives stated that the government officials had a "solid understanding of how to apply an EIA" and they were impressed by their "high standard of work, in particular, the outcomes of their practical exercises on EIA." A key point to emphasize is the importance of ensuring that developments including extraction activities are assessed and monitored appropriately before, during, and after the operational phase.

Environmental safeguards and monitoring of hard rock quarries in Samoa

For many infrastructure projects such as roads, wharfs, and airports, international agencies like ADB require contractors to prepare a Quarry Environmental Management Plan (QEMP) and a project Construction Environmental Management Plan.[464] The QEMP includes a quarry EIA, Quarry Management Plan, Quarry Traffic Management Plan, and Quarry Site Restoration Plan. These documents must be submitted by the contractor to PUMA, which reviews and issues a Development Consent and Quarry Permit. For the Apia Port Project, additional Development Consents were requested by PUMA for the spring water intake for the quarry, for a truck tire wash that is located outside the consented area for the quarry, and for a stockpile area adjacent to the truck tire wash area. The QEMP and Construction Environmental Management Plan were not publicly available. However, it is assumed that the processes are governed by Samoa's environmental regulations and ADB's Safeguard Policy Statement 2009.[465] While it is evident that EIAs and EMPs are carried out for infrastructure projects funded by international agencies, it would be unlikely that commercial quarries are operated against the same standards.

[462] Department of Environment, Niue State of Environment Report 2019. https://niue-data.sprep.org/system/files/Niue-SOE-digital-v8.pdf. Accessed 6/11/2023.

[463] Reliefweb (2016). Niue to Reap Benefits of Environmental Impact Assessment Training. 8 September. https://reliefweb.int/report/niue-new-zealand/niue-reap-benefits-environmental-impact-assessment-training. Accessed 6/11/2023.

[464] Asian Development Bank (2023). Samoa: Enhancing Safety, Security, and Sustainability of Apia Port Project, Environmental and Social Monitoring Report. Semestral Report (January-June 2023), July 2023. https://www.adb.org/sites/default/files/project-documents/47358/47358-002-esmr-en_3.pdf. Accessed 04/10/2023.

[465] Asian Development Bank (2009). Safeguard Policy Statement. Policy Paper. July. https://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf. Accessed 04/10/2023.

Visits by one of the consultants to one of the quarries supplying the port project reveal good quarry management practices and strong oversight by the regulator.

5.1.3 Environmental impacts of coral dredging and sand mining

In most Pacific countries, marine or coastal resources below the high-water mark commonly belong to the customary land / resource owners. Despite the efforts of local governments to ban beach sand mining, both individual and larger-scale activities have been challenging to enforce and monitor due to the ambiguity of resource ownership. This is evident in Tonga, Samoa, and Solomon Islands, where beach mining has led to erosion, destruction of infrastructure, and flooding. In some cases, it is probably sustainable to continue beach mining at a low domestic level for the customary landowners; however, medium- to large-scale activities should be carefully monitored. Limits should be prescribed for aggregate extraction for non-commercial use by landowners.

Lagoon dredging for sand and coral rubble can have significant impacts on coral reefs and fisheries. In many islands, indigenous communities have the right to access and use the land and marine area within or nearby their communities for individual or small-scale fishing. For example, the Laws of Tuvalu Act (Revised 2008) recognizes the customary law, which should be applied when dealing with issues related to the ownership “over or in connection with any area of the territorial sea or any lagoon, inland waters or foreshore, or in or on the seabed, including rights of navigation, fishing or gathering”. Such regulations should be respected when during the project planning process to ensure customary rights are protected and dredging does not adversely impact the livelihood of local people. ESAT and TCAP are good examples, where areas of no significance to indigenous landowners are recommended as sand dredging sites. The country cases presented below provide some insight into the issues being faced in some PICs.

Tonga

Beach sand mining has been the main source of sand for construction purposes in Tonga, despite being banned since 2002 in all but one area (Figure 105).[466] The most recent data indicate that the quantity of sand mined from beaches had increased significantly up until 2014, though more recent data are not available (Figure 105). Nevertheless, recent studies show that s and mining continues to be a problem, causing the main beaches in Tongatapu to move inland in many places, leaving coastal infrastructure and housing more exposed to extreme weather events caused by climate change.[467] Unregulated sand mining activities continue, despite the government’s push towards offshore dredging. In 2014, Monuafe Island became the first islet in Tonga to be submerged due to cyclones and the illegal sand-mining activities.[468]

[466] Kingdom of Tonga (2005). Initial National Communication in Response to its Commitments under the United Nations Framework Convention on Climate Change. https://unfccc.int/resource/docs/natc/tonnc1.pdf. Accessed 04/10/2023.

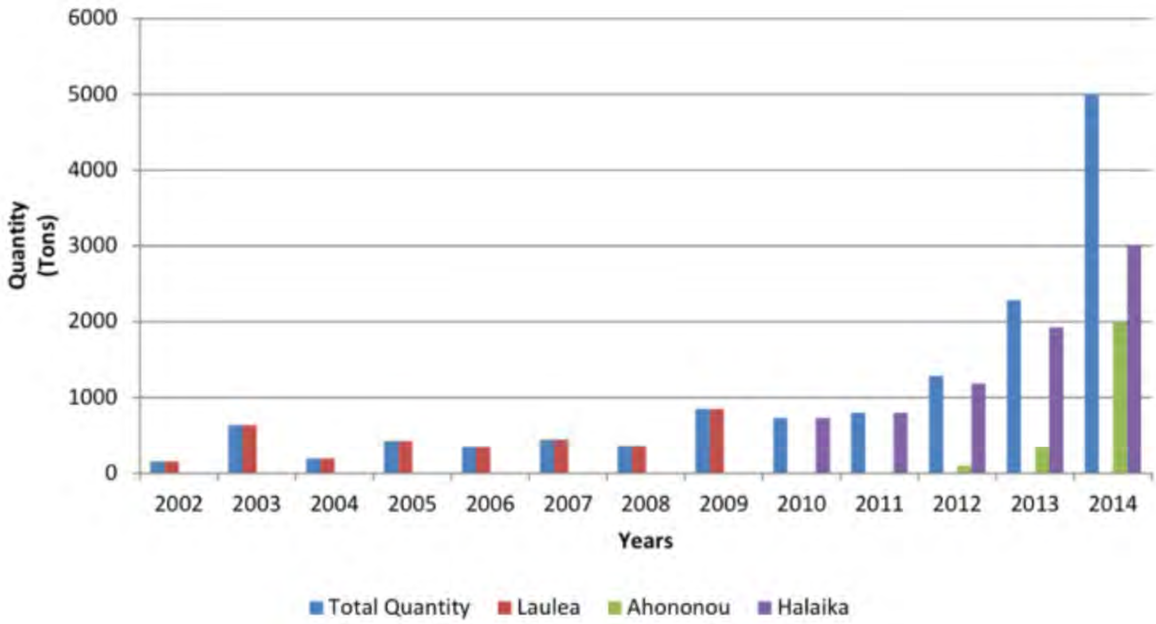
[467] SPREP (2019). *State of the Environment Report 2018*. https://tonga-data.sprep.org/system/files/Tonga%20SOE%20high-res.pdf. Accessed on 4/10/2023.

[468] Matangi Tonga Online (2014). Tongan Islet Disappears beneath the Sea. 9 October. https://matangitonga.to/2014/10/09/tongan-islet-disappears-beneath-sea. Accessed 4/10/2023.

Figure 105: Coastal Erosion Caused by Beach Sand Mining in Tonga

Photo credit: Robert Smith, 1995

Figure 106: Quantity of Sand Mined from 2002 to 2014, Showing the Increase in Demand for Aggregates over the Years



source: SPREP 2018

Samoa

Sand mining and dredging are two of the main issues impacting the conditions of coastal and marine habitats in Samoa. Sand mining activities are regulated and monitored by PUMA through a licensing process that also includes an EIA. The most recent, though now outdated, available State of the Environment report indicates a growing trend in the number of licenses issued throughout the years (2008–2011). It is difficult to determine whether any of these developments have gone through the EIA process, since in average only 2.6% of all development projects (n=855 in 2012) in Samoa went through the EIA/PEAR process.[469]

The main indicators of habitat health for marine environments are coral reefs and fish diversity, and for coastal environments, mangrove health and diversity and conditions of beaches. With the exception of mangrove habitats which are in a relatively good condition, there is no baseline information available about the state of marshes, coastal strands, and beaches.

The volume extracted by regulated extraction activities is managed by MNRE. In 2008 and 2011, the ministry reported 7,630 and 2,183 m^3, respectively, had been extracted. However, most of the mining occurring is unregulated and the volumes remain underreported.[470] Further, there is no knowledge of natural sand-replenishment processes. What is clear are the potential adverse impacts of large-scale dredging in areas when not managed scientifically. For instance, a report by SOPAC in 1991 showed that that dredging of sand from the nearshore area around Mulinu'u Point, on Upolo Island allowed larger waves to approach and consequently erode the approximately 12 m of coastal land at a rapid rate.[471]

Kiribati

Beach sand used to be the main source of aggregates in Kiribati. Several studies reported that extraction of sand resources from areas such as the beaches and lagoons of South Tarawa throughout the years contributed to significant costal erosion.[472] [473] [474] [475] Sand mining, besides being unsustainable and destructive to the environment and coastline, was also not adequate to meet the demand for local development. Hence, to combat the impacts of coastal erosion and climate change on the community, the European Union in collaboration with the SPC's Geoscience Division and the Government of Kiribati's Ministry of Fisheries and Marine Resource Development (MFMRD) established the Environmentally Safe Aggregates for Tarawa (ESAT) project.

[469] Ministry of Natural Resources and Environment (MNRE), Samoa (2013). Samoa's State of the Environment (DOE) Report 2013. https://pacific-data.sprep.org/dataset/samoa-state-environment-reports . Accessed 9/10/2023.

[470] Feagaimaali'I, J. (2020). Push Against Sand Mining Continues. https://www.samoaobserver.ws/category/samoa/58665. Accessed on 9/10/2020.

[471] Carter, R. (1991). Shoreline Erosion on Mulinu'u Point and Related Considerations in Western Samoa. *SOPAC Technical Report* 118. http://rio-samoa.mnre.gov.ws/sites/default/files/TR0118.pdf. Accessed 9/10/2023.

[472] Howorth, R. (1982). Coastal Erosion in Kiribati: Visit to South Tarawa, 22 January–10 February 1982. *CCOP/SOPAC Technical Report* 22, 13 p. & 3 appendices.

[473] Howorth, R. (1983). Coastal Erosion in Kiribati: Visit to South Tarawa, 23 August–8 September 1983. *CCOP/SOPAC Technical Report 31*, 11 p., 4 tables, 7 figs, 3 appendices.

[474] Webb, A. (2005). Technical Report -- An Assessment of Coastal Processes, Impacts, Erosion Mitigation Options and Beach Mining (Bairiki/Nanikai causeway, Tungaru Central Hospital coastline and Bonriki runway -- South Tarawa, Kiribati). *EU-SOPAC Project Report* 46. South Pacific Applied Geoscience Commission, Suva, Fiji.

[475] Pelesikoti, N. (2007). Planning Guidelines for Offshore Aggregates Dredging: Sustainable Development and Management of Marine-Sourced Aggregates. *Pacific Islands Technical Report* EU EDF 8 & 9–*SOPAC Project Report* 128. SOPAC Secretariat, Suva.

After several studies by SPC, the lagoon area north of Betio was assessed and proposed as able to provide a more sustainable and sufficient supply of sand and gravel for construction and coastal protection (Figure 107).[476]

Figure 107: Satellite imagery showing the site selected for the ESAT Project (red) in the lagoon north of Betio, Tarawa Atoll

In 2015, the Ministry of Fisheries and Marine Resources Development (MFMRD) of Kiribati and the SPC team prepared an EIA report on the status of the biodiversity and fisheries prior to the commencement of the dredging activities, and a management and monitoring plan to be carried out during the operations to mitigate the impacts of sand dredging on the environment.[477]

The EIA was detailed and comprehensive including a baseline assessment of the conditions prior to extraction activities so as to assess the impact dredging would have on the environment and recommend measures to prevent such impacts during and after the operations have ceased. For example, the EIA reported that the proposed dredging area was characterized by low fish and benthic invertebrate diversity and live coral cover, though it was identified as an important nursery ground for *Lutjanus gibbus* (Humpback red snapper). However, the impacts were assumed to be minimal as the recovery time of the habitat from the dredging activities would take place from 6 months to 3 years and only 10% of the area would have been impacted by the dredging activities over a 5-year period. Other issues such as increased turbidity and decreased light penetration were not significant to the area as it was already characterized by naturally high sediment loads as result of shallow lagoon water exiting the lagoon on outgoing tides. Based on the low fish biodiversity

[476] Biribo, N. and Smith, R. (1994). Sand and Gravel Usage South Tarawa, Kiribati 1989–1993. *SOPAC Preliminary Report* 75.Ministry of Environment & Natural Resources, Kiribati, SOPAC Secretariat, Suva, Fiji; Smith, R. and Biribo, N. (1995). Marine Aggregate Resources in Tarawa Lagoon, Kiribati - Including Current Meter Studies at Three Localities. *SOPAC Technical Report* 21, SOPAC Secretariat, Suva, Fiji; Richmond, B.M. (1990). Near-Shore Sediment Distribution, South Tarawa, Kiribati. *CCOP/SOPAC Technical Report* 91. South Pacific Geosciences Commission, Suva. Fiji.

[477] Yeeting, B. (2012). Environment Impact Assessment of the ESAT Aggregate Dredging Project in Betio, Tarawa: Impact on the Fisheries Resources. Report prepared for the Ministry of Fisheries and Marine Resources Development (MFMRD), Republic of Kiribati. Secretariat of the Pacific Community.

and the results of a socio-economic assessment the area was also deemed as not being a significant food source for the local communities.

Tuvalu

Tuvalu is currently threatened by sea-level rise. The capital, Fogafale in Funafuti Atoll, has been projected to be flooded by 2050 and 95% of the island's land is projected to be flooded by routine high tides by 2100.[478] The Government of Tuvalu, with the support of UNDP, is creating 7.3 ha of new and raised land as coastal adaption infrastructure in Fogafale and other outer islands (Figure 108).

Figure 108: Tuvalu Coastal Adaptation Project (TCAP) on the Capital Fogafole to Protect Communities from Sea-Level Rise

Source: James Lewis, TCAP Coastal Engineer

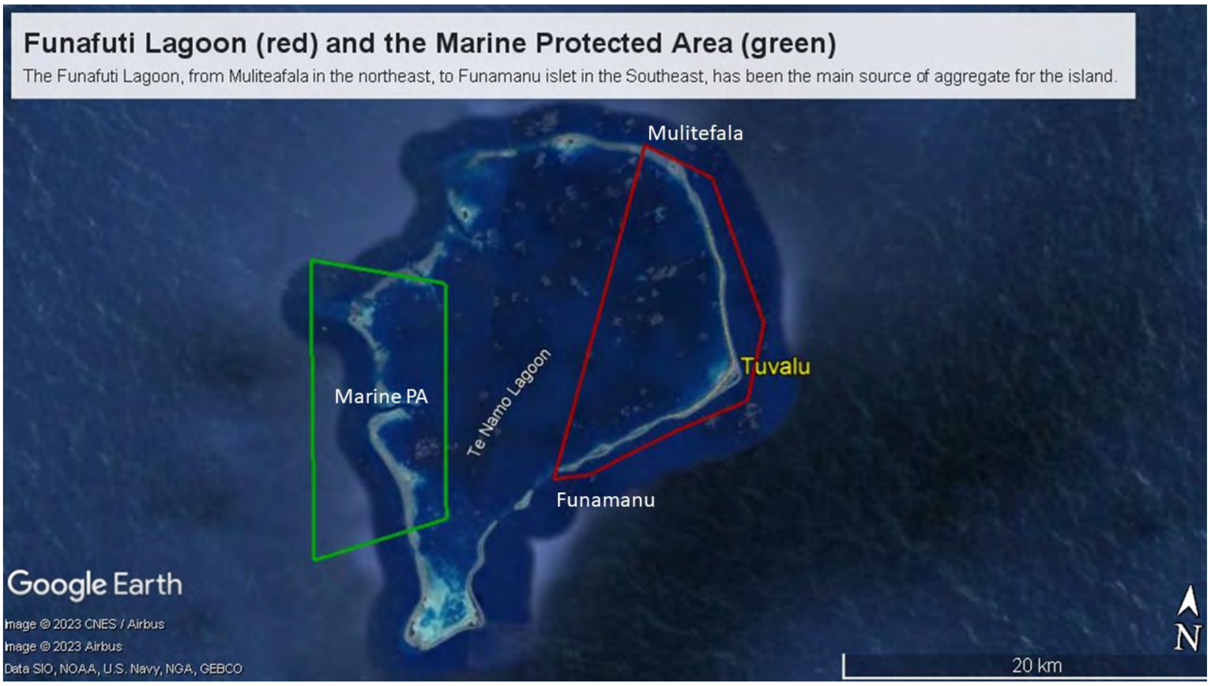
In Tuvalu, the coral reefs cover 710 km^2 across three islands (Funafuti, Nukulaelae, and Nanumea). However, living corals only constitute of 20–30% of the coral cover. Corals are under immense pressure from multiple factors including climate change, cyclones, bleaching events, overfishing, and invasive and predator species.[479] The Funafuti Lagoon, from Muliteafala in the northeast to Funamanu islet in the southeast, has been the main source of aggregate for construction, mostly in the backreef areas due to the low live coral cover (<1%) (Figure 109). The biodiversity of these areas is mostly unknown since it has been studied only in terms of the values as a source of food and protein including sea cucumber species, sea urchins by approximately 700 fish species, with most of the sharks listed as endangered in the International Union for Conservation of Nature Red List of Threatened Species. Among sharks, there are other species, including the bigeye tuna listed as Near Threatened, bumphead parrotfish, the groupers, listed as Vulnerable, and the Maori Wrasse listed as Endangered.[480]

[478] UNDP (2023). https://www.undp.org/blog/notes-tuvalu-leading-way-adapting-sea-level-rise. 19 July. Accessed 09/10/2023.

[479] Morris, C.R. (2008). Mechanisms of Vasculopathy in Sickle Cell Disease and Thalassemia. *Hematology / the Education Program of the American Society of Hematology*. 1: 177–185.

[480] Job, S. and Ceccarelli, D. (2012). Tuvalu Marine Life Scientific Report. Alofa Tuvalu Project with the Tuvalu Fisheries Department and Funafuti, Tuvalu, Nukulaelae Kaupules, 214.

Figure 109: Funafuti Lagoon in red, from Mulitefala in the northeast, to Funamanu islet in Southwest, is the main source of aggregate for the island. The live coral cover within the lagoon is <1%. The Marine Protected Area in green comprises 20% of the total live coral cover in Tuvalu. Any dredging occurring in the eastern side of the atoll is 10 km away from the PA.



Source: Produced by authors using Google Earth Imagery and ArcGIS Pro, 2023

There is little research on the impacts these species face in Tuvalu. However, exploitation via over-fishing, environmental stressors such as increase in ocean temperatures and siltation are known to be the most significant factors impacting biodiversity in the region.[481]

Queen Elizabeth II Park Project

The Queen Elizabeth Park II (QEII) Project was a beach reclamation project aimed to protect the community from the impacts of climate change, erosion, and sea-level rise. It was initially completed in April 2016, and required approximately 115,000 m^3 of sand and limestone, which was dredged from the Fongafale lagoon. However, in less than a year, the park was reported to be highly eroded.[482]

Tuvalu Coastal Adaptation Project

Launched in 2017, TCAP is a project assisting Tuvalu to protect the nation from coastal hazards particularly those related to climate change and sea level rise by developing a long-term coastal adaptation strategy, building capacity of national and local authorities to better implement adaptation actions, and investing in youth. One of its goals is to build coastal protection infrastructure in three of its islands (Funafuti, Nabumea, and Nanumaga).[483]

[481] Ceccarelli, D.M. (2019). Tuvalu, Chapter 32, World Seas: An Environmental Evaluation, 2nd Ed., the Indian Ocean to the Pacific, https://doi.org/10.1016/B978-0-08-100853-9.00041-5.

[482] Yarina, E. and Takemoto, S. (2017). Interrupted Atolls: Riskscapes and Edge Imaginaries in Tuvalu. *The Plan Journal*, 2: 461–95.

[483] Tuvalu Coastal Adaptation Project. https://tcap.tv/about-tcap. Accessed 01/04/224.

TCAP is using a range of coastal protection measures, including ecosystem initiatives, beach nourishment, concrete and rock revetments, and sea walls to port. A total of 2,780 m of highly vulnerable coastline, with houses, schools, and hospitals, will be protected from increasingly intensive wave action and coastal inundation.[484]

This project will increase the coastal protection from 570 m to 2,780 m benefiting approximately 30% of the population. In Funafuti, the coastal protection work is located on the Viaku Foreshore to the east of the QEII Park, consisting of 270,000 m^3 of sediment dredged from the Fogafale lagoon.[485] A 1,330 m Berm Top Barrier will be constructed on the western coast of Nanumea, requiring 37,100 m^3 of sediment sourced from the southern tip and lagoon flanks of Nanumea.[486] Another 665 m of Berm Top Barrier will be constructed on the western coast of Nanumaga, requiring 9,500 m^3 of sediment sourced from the northern tip of Nanumaga located around 500 m from the village center.[487]

Environmental Impact Assessment and Management Plans

There is an EIA prepared for each island where coastal adaptation infrastructure is being built, as well as an EMP, including the three islands.[488] The EIAs prepared for these projects are holistic and comprehensive considering the impacts on physical, biological, and social environment. As is the case with most infrastructure projects, there are several potential impacts and risks that can occur during the construction phase which have been addressed through proper management and monitoring measures. A summary of the possible impacts in the three islands and the corresponding mitigation strategies is provided in the Table 48.

Table 48: Summary of the Environmental Impacts Identified for Each Coastal Adaptation Project in Funafuti, Nabumea, and Nanumaga and the Corresponding Mitigation Measures Identified in the Environmental Management Plan.

Impacts	Mitigation Strategies
Dredging and Fill Works	• Develop and implement site-specific Dredge Management Plan • Routine monitoring through a Water Quality Sampling and Analysis Plan • Dredging limited to the area identified in the EIA, characterized by low live coral cover
Erosion, Drainage and Sediment Control	• Develop and implement an Erosion, Drainage and Sediment Control Plan. • Determine sustainable sand extraction sites and volumes • Ensure that beach is rehabilitated
Noise and Vibration	• Minimize nuisance from noise, especially closer to residential areas and sensitive receptors

484 UNDP – Tuvalu Coastal Adaptation Project. https://www.adaptation-undp.org/projects/tuvalu-coastal-adaptation-project. Accessed 09/10/2023.
485 UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/resources/reports-and-publications-country-teams/detailed-design-report-tcap-funafuti-island-march. Accessed 09/10/2023.
486 UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/resources/reports-and-publications-country-teams/detailed-design-report-tcap-nanumea-island-march. Accessed 09/10/2023.
487 UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/resources/reports-and-publications-country-teams/detailed-design-report-tcap-nanumaga-island-march. Accessed 09/10/2023.
488 UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/projects/tuvalu-coastal-adaptation-project. Accessed 09/10/2023.

	• Signage to outline complaints procedure and contact details of recipient of complaints • Contractor will develop a work schedule or operations to identify hours and days of no work due to religious and cultural activities
Community Services and Infrastructure	• Waste management practices will prioritize reduce, reuse, recycle • Disposal of waste shall be carried out in accordance with the Government of Tuvalu requirements • Contractor will provide first aid facilities and trained first aiders for all workers
Hazardous Substance Management	• Prepare spill management plan addressing measures • Store and handle all chemicals, fuels, oils and potentially hazardous materials
Explosives	• The dredge will be fitted with a suitable screening mechanism to exclude ERW • The Contractor will detail their protocols for safely handling and disposing of ERW in the event that any are encountered during construction
Social Environment	• Ensure opportunities to incorporate men and women's views and interests into project decisions and implementation • Develop and implement a communication plan for the project • Ensure that job opportunities are fairly disseminated
Biological Environment	• No permanent gaps will be created in the vegetation line. All trees and plants will be avoided if possible and any which are removed will be replanted or replaced on completion of works • Create a nursery from species existing on the island in preparation for replanting • All imported materials, equipment and aggregate will be subject to importation under the quarantine and biosecurity regulations of Tuvalu
Land and Resource Use	• Conduct an inventory of food producing trees that will be cleared and ensure seedlings are replanted in areas that are accessible to households that rely on cleared trees

ERW = explosive remnants of war.

Source: UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/Tuvalu-Coastal-Adaptation-Project-TCAP-ESIA-Funafuti. Accessed 09/10/2023; UNDP – Tuvalu Coastal Adaptation Project https://www.adaptation-undp.org/Tuvalu-Coastal-Adaptation-Project-TCAP-ESIA-Nanumaga-Nanumea. Accessed 09/10/2023.

Federated States of Micronesia

Dredging of coral rubble and mining of sand have been a major source of aggregate in the FSM due to the high cost of hard rock and gravel. Little is known about the impacts of dredging and sand mining in the FSM, except that it is a serious environmental problem in three out of the country's four states, with difficulties controlling the negative impacts especially on local fisheries.

A SOPAC study investigating the impacts of dredging in Pohnpei State reported low water quality with high turbidity levels and inundation with little to no marine plants, resulting in low food availability and altered spawning behavior and overfishing.[489] However, the full scale of impacts was hard to estimate due to a lack of baseline data and monitoring by the local Environmental Protection Agency (EPA). It was also noticed that there is a lack ofpersonnel within

[489] Smith, R. et al. (1998). Impacts of Dredging for Aggregates from Fringing Reefs: Pohnpei State Recommendations and Alternatives. *SOPAC Technical Report* 257.

the EPA who are qualified to understand, assess, and develop EIAs that are required under the current Earthmoving Regulations.

Other than the serious environmental impacts, it was also reported that the current dredging operations were not paying royalties and some operators recommenced dredging on some of the closed pits without the EPA being fully aware of it. It was also concluded that rehabilitation of closed pits had never been enforced and it was unclear in the Earthmoving Regulations which agency was responsible for enforcing site rehabilitation.

Another SOPAC report discusses the impacts of lagoon sand mining in Nett Municipality in Pohnpei State.[490] Sand reserves were estimated to be 520,000 m^3 and 360,000 m^3 for each site, respectively. These volume estimates could supply the aggregate demand for 20–30 years following the study if extraction occurred in sustainable rates. Due to a lack of records on material volumes extracted, it would be hard to determine whether extraction is currently occurring is sustainable.

The Marshall Islands

SOPAC and the RMI Environmental Protection Authority have conducted biological marine assessments for proposed dredging sites within the Majuro Lagoon.[491] These environmental assessments provide a baseline study of the environmental conditions prior to dredging and suggest areas suitable for dredging where the impacts to the environment can be minimized.

There is great potential for sustainable extraction of sand in Majuro through a mobile dredging system that utilizes more than one deposit to reduce overexploitation and consequently reduce environmental impacts.[492] The productivity of the reefs should also be studied in order to quantify sustainable extraction rates for future developments.

In addition, the government has stated that the low population densities in most of the outer islands of the country appear to have mostly minimized the impacts on shoreline change and coastal inundation through activities such as sand mining, reef rubble and beach rock removal, inappropriate reclaiming of beach areas and seawall construction, and destruction of the natural vegetated berm. It concluded that "while these activities do occur with localized issues, the resulting impacts on shoreline change and increasing exposure to coastal inundation do not appear to be as widespread or as severe as in many other outer atoll islands in the Pacific."[493]

Palau

Dredging for gravel, sand, and coral aggregates appears to be the only type of mining activity occurring in Palau and one of the most significant factors impacting the environment. A recent report suggested that sand and reef dredging is one of the main causes of two out of six environmental priority problems facing Palau's marine environment, namely resource depletion and ecosystem

[490] Smith, R., Edward, A. & Shorten, G. (1997). Sand Dredging, Nett Municipality Pohnpei Lagoon, Federated States of Micronesia, Resource Assessment and Environmental Considerations. *SOPAC Technical Report* 244. Suva, Fiji.

[491] https://repository.library.noaa.gov/view/noaa/39959; Lindsay, S. (2008). Rapid Biological Marine Assessment of the Proposed RMI-EPA Sand and Aggregate Dredging Site Locations within Majuro Lagoon, Republic of the Marshall Islands. *SOPAC Technical Report* 409.

[492] Smith, R. and Collen, J. (2004). Sand and Gravel Resources of Majuro Atoll, Marshall Islands. *SOPAC Technical Report* 360.

[493] Government of the Republic of the Marshall Islands (2020). Adaptation Communication – Republic of the Marshall Islands (RMI) Adaptation. December. https://unfccc.int/sites/default/files/resource/RMI-AdaptationCommunication_Dec2020.pdf. Accessed 16/12/2023.

degradation.[494] Dredging in Palau involves removal of soft sediment and hard rock from the ocean floor for construction, opening up navigation channels, reclaiming new land, and sand mining.

Most of the dredging sites in Palau are associated with construction and development projects and are located in shallow areas along the coast. For example, the dredge sites around Babelthuap were associated with the construction of the Palau Compact Road. Meanwhile, offshore dredging has been used for mining of high-quality coral sand. These activities have two main ecological impacts on the marine environment. The first is that it increases suspended sediment, which can be transported by currents. Second, dredging can result in depressions at the seabed. Such altered and unstable sediment regimes make it difficult for benthic communities and fish to recolonize the disturbed areas. For example, the German Channel, in the southern part of the Rock Islands, has still not be recolonized by species, despite dredging ceasing during the early part of the 20th century.[495] Furthermore, the production capacity of reefs had decreased significantly over a period of 10 years. The decline, however, is most likely caused by the cumulative impacts of several factors in addition to dredging, including over-harvesting, the 1998 coral bleaching event, and run-off from inland development activities.[496]

Such impacts have also interfered with people's livelihoods. In 2018, the Ngarchelong State Government and the Japanese RAM Corporation reached an agreement to mine the reef around the state. The community expressed serious concerns as the company proposed dredging an unlimited amount of sand for 50 years. The company was required to pay 35% of the sand-mining profits to the state, without having to pay lease or royalties to the local community.[497] The area is also an important biodiversity hotspot, and the local community depends on subsistence fishing and food gathering in the areas surrounding the site. There was also a lack of communication and consultation about the project between the stakeholders and communities. Despite voicing their concerns, the proposed project went ahead, and the company is planning to expand the operation to other states in Palau in the future.[498]

5.1.4 Landowner issues

Hard/soft rock quarrying

Land issues related to hard-rock quarrying are related to land resource access (rock and/or water) and issues related to the negative impacts these activities may have on the livelihood of the communities (noise and air pollution, clean water availability, road access, royalties, etc.). In Fiji, for example, hard rock quarries have better community relations with the communities due to the long-term nature of the quarries and their contributions such as royalty revenue, employment opportunities and improvement of infrastructure. Unlike river gravel extraction activities, regulated quarries in Fiji have complaint record books to register community complaints.

[494] Island Times (2018). Palauans, netizens lambast proposed 50-year commercial sand mining project in Ngarchelong. 13 November. https://islandtimes.org/palauans-netizens-lambast-proposed-50-year-commercial-sand-mining-project-in-ngarchelong/ Accessed 16/12/2023.

[495] Colin, P. (2009). Marine Environments of Palau. Mutual Publishing. Honolulu. https://palau-data.sprep.org/system/files/Colin-PL-2009-Marine-Environments-of-Palau.pdf. Accessed 16/12/2023

[496] ADB (2008). Environment Vis-À-Vis Development: Review of the Impacts of Public Infrastructure and Identification of the Opportunities and Constraints the Environment Offers Development. Working Paper. Project Number 40595. September. https://www.adb.org/sites/default/files/project-documents//40595-08-pal-tacr.pdf. Accessed 16/12/2023.

[497] Island Times (2018). Palauans, netizens lambast proposed 50-year commercial sand mining project in Ngarchelong. 13 November. https://islandtimes.org/palauans-netizens-lambast-proposed-50-year-commercial-sand-mining-project-in-ngarchelong/ Accessed 16/12/2023.

[498] Island Times (2019). Japanese Firm behind Ngarchelong Sand Mine Expands Operation. 12 March. https://islandtimes.org/japanese-firm-behind-ngarchelong-sand-mine-expands-operation.

However, land access remains the most challenging issue in hard (and soft) rock quarry operations in some PICs. For example, the land at Quoin Hill, on Efate Island, Vanuatu has been reported to have a good quality basaltic outcrop suitable for construction material.[499] However, the land falls under customary land tenure and the project has been opposed by local villagers and the people of Nguna Island, one of the offshore islands in the north of Efate for several years. There has been an ongoing court case trying to determine the rightful owners.

Vanuatu does not have a system of customary land registration and there is no method of recording land-owning groups as a single entity in order to enter land use agreements with developers or government agencies.[500] What is needed are land trusts, which some villages like Mele and Ifira on Efate have established to facilitate land leasing processes with investors, though not specifically for quarrying activities. The Ifra land trust has been successful at delivering benefits to the community. On the other hand, the Mele land trust has been less successful at engaging in responsible business practices.

International organizations, such as ADB, have safeguards in place when dealing with Indigenous Peoples in Asia and the Pacific.[501] These safeguards aim to manage issues that arise when a project has direct or indirect impacts on Indigenous Peoples, such as their livelihood systems and territories or natural or cultural resources. The general requirements for engaging with Indigenous Peoples are outlined in the ADB's Safeguard Policy Statement. A summary is provided in Appendix A.

5.1.5 River sand and gravel extraction

River extraction sites are located in dynamic ecosystems, with aggregate deposits that are often mobile and short-term in nature, with extractive activities moving fairly regularly. In countries like Fiji, this has occasionally led to conflicts with customary landowners in communities along the river systems who depend on the rivers for their livelihood. In Fiji, river extraction sites, with the exception of the larger ones with combined beneficiation, tend not to have a complaints record-keeping system in place.[502]

In Solomon Islands, the Poha River has good quality river sand and gravel deposits composed of diorite, granite, and tonalite.[503] However, due to landowner dissatisfaction about the nonpayment of compensation and royalties, aggregate extraction at some sites has ceased. Furthermore, when dealing with different people from the same clan, developers are usually confronted with the difficulty of having to negotiate with people that have different views. Before setting up an operation operators must involve the Mines Division, as representatives of the national government, and the provincial government in assisting with the consultation process. For landowners, the best option is to nominate an official representative or a selected committee to speak and negotiate with the developers and institutional agencies on their behalf. This outline of the consultation process, recommended in the Proposed Aggregates Guideline for Solomon Islands report is shown in the (Figure 110). The same process would be recommended when dealing with several communities, where a representative from each community would be part of a negotiating committee.

[499] Tawake, A. (2005). Technical Report on Geological and Geo-Technical Assessment of the Quoin Hill Volcanic Rocks, Efate, Vanuatu, as a Potential Aggregates Source. EU EDF 8 – *SOPAC Project Report* 48.

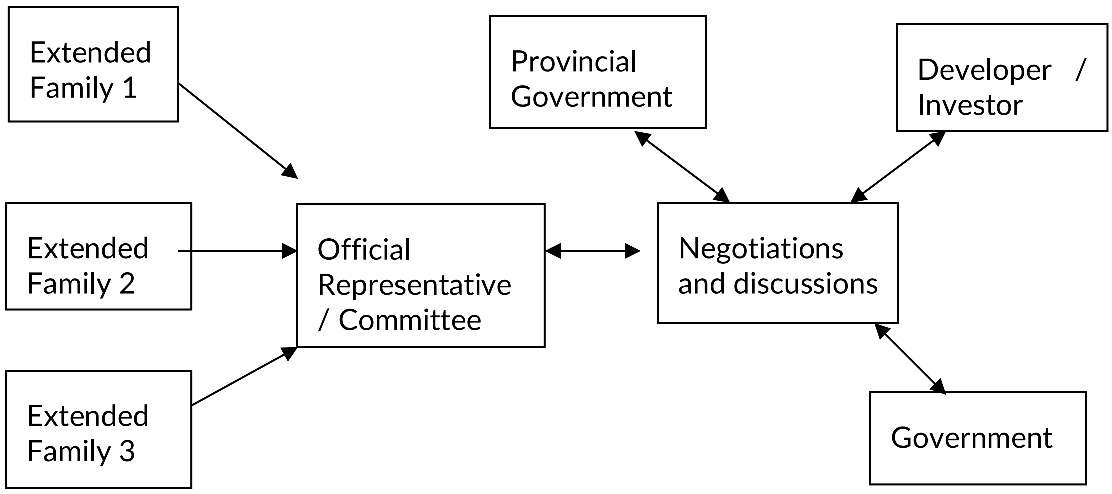
[500] Commonwealth of Australia (2008). Reconciling Customary Land and Development in the Pacific: Volume 1. AusAID. https://www.dfat.gov.au/sites/default/files/MLW_VolumeOne_Bookmarked.pdf. Accessed 16/12/2023.

[501] Asian Development Bank (2009). *Safeguard Policy Statement*. https://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf. Accessed 16/12/2023.

[502] Smith, R. et al. (2018). Baseline Assessment of Development Minerals in Fiji. Suva, Fiji: United Nations Development Programme.

[503] Tawake, A. (2005). Solomon Islands Country Mission and Technical Advisory Report: Stakeholder Consultations and Aggregates Source Assessment in Honiara and Ghizo Island, Western Province. EU EDF 8 – *SOPAC Project Report* 57.

Figure 110: Summary of the Landowner Consultation Process



Source: Tawake, A. (2006). Proposed Guidelines for Sustainable Aggregates Development and Management in the Solomon Islands. EU EDF 8 – SOPAC Project Report. Draft Copy.

5.1.6 Safeguard requirements: environment

Various donors, including the ADB and World Bank have their own environmental policies and safeguards, including guidance on the conduct of EIAs. This section provides an overview of the recommended contents of an EIA report using ADB's safeguard policies as an example. Readers are encouraged to refer to the World Bank and other donors' policies for other examples.[504]

The ADB Safeguard Policy Statement outlines the requirements that clients and contractors are required to meet for undertaking environmental impact assessment processes in the context of ADB funded projects. The requirements include assessing and managing impacts, preparing environmental assessment reports, disclosing information and undertaking consultations, establishing a grievance mechanism, and monitoring and reporting. The document also includes specific environmental safeguard requirements for environmental issues such biodiversity conservation and sustainable management of natural resources, pollution prevention and abatement, and occupational and community health and safety. Table 49 summarizes the typical elements contained in an EIA report, as described in the Safeguard Policy Statement.

Table 49: Summary of the Environmental Impact Assessment Report Outline, ADB Safeguard Requirements

Section	Description
Executive Summary	Describes concisely the critical facts, significant findings, and recommended actions.
Policy, Legal and Administrative Framework	Discusses the national and local legal and institutional framework within which the environmental assessment is carried out

504 World Bank (n.d.). Environmental and Social Policies. https://www.worldbank.org/en/projects-operations/environmental-and-social-policies. Accessed 04/04/2024.

Description of the Project	Describes the proposed project; its major components; its geographic, ecological, social, and temporal context, including any associated facility required by and for the project (for example, facilities, access roads, power plants, water supply, quarries and borrow pits, and spoil disposal); and its geographic, ecological, social, and temporal context.
Description of the Environment (Baseline Data)	Describes relevant physical, biological, and socioeconomic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project.
Potential Environmental Impacts and Mitigation Measures	Predicts and assesses the project's likely positive and negative direct and indirect impacts to physical, biological, socioeconomic conditions (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods through environmental means, and physical cultural resources in the project's area of influence). Identifies mitigation measures and any residual negative impacts that cannot be mitigated; explores opportunities for enhancement; identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics that do not require further attention; and examines global, transboundary, and cumulative impacts as appropriate.
Analysis of alternatives	Examines alternatives to the proposed project site, technology, design, and operation—including the no project alternative—in terms of their potential environmental impacts.
Information Disclosure, Consultation, and Participation	Describes the process undertaken during project design and preparation for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders.
Grievance Redress Mechanism	Describes the grievance redress framework (both informal and formal channels), setting out the time frame and mechanisms for resolving complaints about environmental performance.
Environmental Management Plans	This section deals with the set of mitigation and management measures to be taken during project implementation to avoid, reduce, mitigate, or compensate for adverse environmental impacts (in that order of priority) including description of mitigation measures, monitoring process and implementation arrangements.
Conclusions and Recommendations	Provides the conclusions drawn from the assessment and provides recommendations.

Source: Asian Development Bank (2009). Safeguard Policy Statement. https://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf. Accessed 16/12/2023.

5.2 Economic contribution of the aggregates sector

The quarry sector is an important contributor to local, regional, and national economic development, particularly in developing countries, benefitting not only the people who work in quarries but also surrounding businesses and the government. Beneficial effects include creating local employment, generating revenue from taxes and royalties, and creating economic multipliers, such as the development of new businesses resulting from increased demand for goods and services. The quarry sector may also have indirect positive effects on the broader local economic structure through public and private investment in roads, power networks and other infrastructure.

The quarry sector also supports the building and construction industries by providing critical materials, such as aggregates, sand, concrete, and dimension stones required for the construction of houses, public buildings, roads, airports, and energy projects, among others. In Australia, for example, building a 1 km, two-lane highway and an average new house requires about 14,000 tons (or 400 truckloads) and 110 tons of construction aggregates, respectively.[505]

The quarry sector also plays a critical role in climate change adaptation and response in the Pacific Islands since it provides the materials essential for constructing seawalls, reclaiming land, and building climate-resilient infrastructure.[506] Table 50 below summarizes the economic contribution of the quarry sector.

Table 50: Economic Contribution of the Quarry Sector

Economic contribution
Direct and indirect employment and income generation for the local population especially as quarry managers, crusher operators, mechanics, drivers and truck drivers, explosive specialists, laborers, and safety officers among others
Taxes and royalty revenue for local people/landowners and government
Local business development such as hospitality services, equipment hire/sales, fuel sales, banking services
Company contribution to the local community such as through corporate social responsibility projects
Capacity skill development through skilling up workers
Improved local infrastructure such as roads, water, energy, etc.

Source: Produced by authors, 2024

This section examines the economic contribution of quarrying, focusing on both revenue generated and employment numbers. Publicly available data for most countries is very limited and what is presented here is a partial view of the impact in specific countries determined through this data or acquired during field trips to Fiji, Samoa, Solomon Islands, and Vanuatu. A more comprehensive assessment of the economic contribution of the sector would require additional primary data collection in the countries not covered below.

5.2.1 Samoa

There are no official data on the numbers of people employed in the quarry sector or supporting industries in Samoa. However, the Lauli'i quarry run by China Harbour Engineering Corporation to provide materials for the Apia Port project reportedly has around 15 workers, some of whom are local, with the rest from the PRC and Sri Lanka.

Official data on royalties from hard rock quarrying operations are also not available. The only available information is the revenue generated by sand-mining application fees. As shown in Table 51, between 2012 and 2020 the quarry sector generated ST193,781.85 ($68,599) from these application fees

[505] Cement, Concrete and Aggregates Australia (CCAA).
https://www.ccaa.com.au/CCAA/Public_Content/INDUSTRY/Quarry/Quarry_Overview.aspx

[506] Rogers, P. et al. (2023). *Building Disaster and Climate Resilience through Development Minerals*. Brisbane, QLD, Australia: The University of Queensland. https://doi.org/10.14264/9052c85.

though there was a significant decrease in revenue in 2020–2021.[507] This is anticipated to have been impacted by the effects of COVID-19.

Table 51: Revenue from Sand-Mining Application Fees in Samoa

FY	Permits Issued	Total Revenue (WST)
2012–2013	55	33,440.00
2012–2014	42	12,775.00
2014–2015	62	19,326.85
2015–2016	33	15,290.00
2016–2017	34	21,265.00
2017–2018	43	33,275.00
2018–2019	No data	26,430.00
2019–2020	No data	27,485.00
2020–2021	40	4,495.00
Total	309	**193,782.00 (~$68,599)**

Source: Ministry of Natural Resources and Environment annual reports. https://www.mnre.gov.ws/publications/. Accessed 29/11/2023.

5.2.2 Vanuatu

Quarrying is a key sector in Vanuatu, which generates significant revenue for the country. A royalty of Vt600 (~$5) is paid for every cubic meter of basalt aggregates extracted, while Vt200 (~$1.70) is paid per cubic meter for coronus (limestone) aggregates. This royalty is distributed among the customary landowner owner, the provincial government and the local government depending on the quarry ownership arrangements. As per the Quarry Act 2013, if a customary landowner holds less than 30% of the share of the quarry operating on his/her land, the royalty is distributed as 40% to the landowner, 40% to the provincial government and 20% to the local government. Meanwhile, if the landowner holds more than 30% of the quarry company operating on his/her land, then the royalty is distributed as 80% to the provincial government and 20% to the local government.[508]

Between 2014 and 2022, the quarry sector generated a total revenue of Vt483,499,776 ($4.24 million)[509] from the royalties from coronous (limestone) aggregates alone, with a peak in 2019 of Vt181,020,800 ($1.58 million), as shown in Table 52 below. However, this figure does not include the quarries operated and managed by the PWD since data on the volumes extracted were not available at the time of fieldwork. As with other countries such as Samoa, the revenue declined from 2020 and this is anticipated to be due to the COVID-19 pandemic. Basalt aggregate production is not common on most Islands in Vanuatu but the official data do show limited production from quarries in islands such as Malekula, Espirito Santo, and Tanna. For the same period, only 5,751 m^3 of basalt were extracted, translating to Vt3,450,600 ($30,231) in revenue.

Apart from the revenue from royalties, the government's revenue also comes in the form of application fees for the quarry leases. A fee of Vt5,000 is charged for every quarry lease application made to the Department of Geology and Mines.

[507] Based on a conversion rate of ST1 = $0.354 as of 23/03/2024.

[508] Quarry Act No.9 of 2013.

[509] Based on an exchange rate of Vt112.14 = $1 as of 23/03/2024.

Table 52: Royalties from Coronus Aggregates, 2014–2022

Fiscal Year	Volume Extracted (m^3)	Total Revenue (@200 Vt/m^3)
2014	23,225	4,645,000
2015	136,378	27,275,500
2016	206,619	41,323,836
2017	370,560	74,112,000
2018	558,344	111,668,840
2019	905,104	181,020,800
2020	95,133	19,026,600
2021	68,384	13,676,800
2022	53,752	10,750,400
Total	**2,417,499**	**483,499,776 (~$4.04 million)**

Source: Calculated from data provided by the Vanuatu Department of Geology and Mines

5.2.3 Solomon Islands

In Solomon Islands, the quarry sector supports local communities by providing employment and the materials required to build their houses, roads, schools, and other infrastructure. According to 2012–13 government labor statistics (the most recently available data), quarrying employed a total of 1,017 persons.[510] In addition, the quarry sector is a source of revenue for the government. Any party who intends to extract aggregates (both sand and gravel) is required to obtain a BMP issued by the Director of Mines, with an application fee of SI$2,500 for a fixed term estate lease.

In addition, royalties between SI$150–180 are paid per 10 m^3 of materials produced. The quarry company is also required to pay a mineral right tenement of SI$16,000 per year to the landowner. Meanwhile, a rental fee ranging from SI$20,000 to SI$50,000 is also paid to the landowner(s). For example, one company paid SI$50,000 ($5,850) to the landowners for their quarry to extract gravel and sand for a term of 5 years.[511] However, in the event of downtime, the quarry operator was required to pay a monthly fee of SI$2,500 to the landowner.

5.2.4 Papua New Guinea

Unlike the large-scale mining sector, there is limited information on the economic contribution of the quarry sector in PNG, in part because of the lack of a central government agency responsible for regulation. For instance, PNG's mining regulator, the Mineral Resources Authority, only regulates quarries developed as part of large mining leases, and so only covers a fraction of the true number of aggregate and quarrying operations across the country.[512] Nevertheless, as described earlier in the country profile, 20 operating quarries were identified during the course of this study, each of which would be generating employment, taxation, and royalty revenues and having broader multiplier effects. Large development projects, including those in the mining and oil and gas sectors also stimulate demand from existing and new quarries.

[510] Solomon Islands National Statistics Office (2015). Solomon Island 2012/13: Household Income and Expenditure Survey. National Analytic Report-Volume 1, Ministry of Finance and Treasury, Honiara.

[511] Based on a currency conversion rate of SI$1 = $0.117 as of 07/04/2024.

[512] Personal communication with Mineral Resources Authority officer. Dated 21/09/2023.

A good example of this is the recent Highlands Region Road Improvement Investment program, which required aggregates from two existing quarries (Elu and Kabulbul) and two new quarries (Tomiare and Kumarini).[513] The landowners had an memorandum of agreement to sell their aggregates at a rate of K13/m^3. Apart from selling the extracted materials, the landowners worked as flagmen, security guards, crews, and machine operators. Also, on the Nipa-Munihu road sub-project, the landowners received royalties totaling K59,535 ($15,233).[514] For this specific project, there were a total of six quarries.

5.2.5 Fiji

As documented in the 2018 Baseline Assessment of Development Minerals in Fiji, the quarry sector's contribution to the Fijian economy is significant, and it has the potential to contribute to further economic growth and development if managed responsibly, particularly as Fiji's role as the regional hub for aggregate exports grows.

The sector contributes significantly to the country's construction, infrastructure and agriculture sectors and is also an important source of landowner and government revenue. However, the revenue reported is much lower than the actual revenue for several reasons, of which unregulated river and quarry sites are the main ones. For instance, the baseline assessment determined that there were 27 unregulated river gravel operations and three unregulated hard and soft rock quarries.[515]

The quarry sector has the potential to benefit local communities in a variety of ways, such as generating income for landowners and providing both direct and indirect employment opportunities for local people, as well as the broader Fijian community. For example, the baseline assessment estimated that the sector provided direct employment to 2,325 Fijians.[515] This estimate is almost consistent with the 2018 and 2019 Fiji government national statistics of 2,055 and 2,440 people, respectively. The national statistics data also show that around 10% (244) of the total quarry sector workforce were women.[521] The employment of women in the quarry sector is the result of a direct commitment of the Fiji government towards the contribution to the UN Sustainable Development Goals, especially SDG-5 on gender equality and empowerment for all women and girls. The current Permanent Secretary, Dr Raijeli Taga, was instrumental in changing Fiji's policy to allow women to take operational, as opposed to only administrative roles, in quarries.

Information on gross output and revenue generated by the quarry sector operations is underestimated. However, the 2018 baseline study did estimate that if all quarries were taken into account, the sector would contribute between F$190.3 million and F$369.1 ($93.25–189.86 million) to the country's gross domestic product (GDP).[516] This contrasts markedly with the official amount of only F$52.40 ($25.68) million in 2018.

Another significant economic contribution of the quarry sector in Fiji is from royalties paid by quarry operators to landowners. The Department of Lands (DoL) issues extraction licenses for quarries in rivers. For quarries located on *iTaukei* land, it is the TLTB that is responsible for license issuance. Out of the total royalty paid to the landowners under the TLTB license, 15% is paid to the TLTB as trustees for collection and administration charges.[517] However, there is a significant discrepancy in the rates charged by the two entities. For example, the DoL charges F$2.50/m^3 for river gravel extraction, while TLTB charges F$3.31/m^3 for hard rock extraction and F$6.61/m^3 for sand and gravel. The

[513] Asian Development Bank (2020). PNG: Highlands Region Road Improvement Investment Program– Tranche 3 Pangia-Wiru Loop Road Sub-Project. Environmental Monitoring Report, January.

[514] Based on a currency conversion rate of K1 = $0.255 as of 07/04/2024.

[515] Smith, R. et al. (2018). Baseline Assessment of Development Minerals in Fiji. Suva, Fiji: United Nations Development Programme.

[516] Based on a 2018 average conversion rate of F$1= $0.49.

[517] Section 14(1) of the iTaukei Lands Trust Act, Cap 134.

discrepancy is also noticed in the quarry license application fees with for F$3.00 and F$5,192.50 by DoL and TLTB, respectively.[515] However, the significantly higher TLTB application fee relative to those of the DoL can potentially limit local investment into the sector.

As already noted above, both the state and the landowners benefit from the royalties from quarry operations. Under the DoL royalty system, out of the F$2.50, F$2.00/m^3 is paid to the state and F$0.50/m^3 to the landowners as compensation for the loss of traditional fishing rights. The 2018 Baseline Assessment reported that based on biannual aggregate extraction at an operation on the Navua River, royalties of F$122,420.00 ($67,562) and F$31,450.00 ($17,297) were paid to the state and the freehold landowners (*qoliqoli* owners) respectively in 2013, as shown in Table 53.

Table 53: Department of Lands Royalty Example from Navua River, 2013

Month	Volume Extracted (m^3)	Royalty rate paid to state @ F$2.0/m^3)	Royalty rate paid to freehold owners as fishing rights @ F$0.50/m^3)
Month 1	5,190	10,380.00	2,695.00
Month 2	4,125	8,250.00	2,062.50
Month 3	6,125	12,250.00	3,062.50
Month 4	4,605	9,210.00	2,302.50
Month 5	8,745	17,490.00	4,372.50
Month 6	1,920	3,840.00	960.00
Half-year total	**30,710**	**61,420.00**	**15,725.00**
Annual forecasted total	**1,420 m^3**	**F$122,840.00 ($67,562)[a]**	**F$31,450.00 ($17,297)**

[a] Based on a 2013 average conversion rate of F$1 = $0.55.

Source: Smith et al. 2018

Meanwhile, under TLTB, with the same total half-year extraction volume of 30,710m^3, the landowners would receive more royalties (up to F$405,986.20/$198,933) if the extraction was on iTaukei land, as shown in Table 54. As noted from the two rates, the TLTB's royalty payments are almost 13 times more than those received by the DoL.

Table 54: TLTB Royalty Example

Month	Volume Extracted (m^3)	Royalty rate paid to *Qoliqoli* owners (F$) 6.61/m^3)
Month 1	5,190	34,305.90
Month 2	4,125	27,266.25
Month 3	6,125	40,486.25
Month 4	4,605	30,439.05
Month 5	8,745	57,804.45
Month 6	1,920	12,691.20
Half-year Total	**30,710**	**202,998.10**
Annual forecasted total	**61, 420 m^3**	**F$405,986.20 ($198,933)**

Note: 1 F$= $0.49 as at 2018 (average annual conversion rate)

Source: Smith et al. 2018

5.2.6 Regional comparisons of gross domestic product and employment contributions

Gross domestic product

Table 55 shows the contribution of quarrying and mining to the GDP of countries for which data are available. For other countries, either the GDP contribution of the sectors is recorded as zero, or they do not have current data. For example, the Nauru Bureau of Statistics' last record was in 2009 with a figure of ~$8 million.[518] Meanwhile, Tuvalu recorded a GDP contribution of zero from 2007 to 2018,[519] despite having lagoon sand mining for local infrastructure construction.[520] Complicating matters is that in most countries, the quarry and mining sectors are combined in national statistics, which makes it challenging to determine the contribution of each to GDP.

However, in the case of Kiribati, Tuvalu, and Tonga, all revenue from mining and quarrying would be from quarrying (aggregate extraction), since none of these countries have non-quarry mining operations, such as gold mining, etc. For Solomon Islands, the GDP contribution of the sector would encompass both sectors, since it has operational gold and nickel mines, and these likely account for the vast bulk the GDP contribution. By contrast, Fiji only has one operational gold mine (Lion One's Tuvatu Mine), but the bulk of the GDP contribution is coming from the quarrying and river gravel (aggregates) sectors.

Table 55: Quarrying and Mining Contribution to Gross Domestic Product across Select Pacific Countries ($M)

FY	Fiji[521]	Kiribati[522]	Tuvalu[523]	Tonga[524]	Solomon Island[525]
2014	28.32	0.34	0	2.72	12.48
2015	32.95	0.70	0	2.76	13.38
2016	34.98	0.84	0	2.46	5.22
2017	27.4	0.53	0	2.54	5.22
2018	23.11	0.72	0	2.9	No data
2019	26.77	0.39	0	2.24	No data
2020	25.5	0.59	0	2.05	No data
2021	23.64	0.57	0	2.35	No data

518 Nauru Bureau of Statistics (n.d.). https://nauru.prism.spc.int/nauru-documents. Converted from an average 2009 rate of A$1 = $0.79.

519 As reported by Tuvalu Central Statistics Division. https://stats.gov.tv/economics/national-accounts/gdp-2018/.

520 Nukufetau Costal Works Project (n.d.). https://www.hallcontracting.com.au/projects/donors-and-international-aid/nukufetau-coastal-works-project.

521 Fiji Bureau of Statistics. Nominal GDP by Industry. See https://www.statsfiji.gov.fj/statistics/economic-statistics/national-accounts-gdp.html. Accessed 29/11/2024.

522 Kiribati National Statistics Office. See https://nso.gov.ki/statistics/economy/gdp/. Accessed 29/11/2024. Note: Kiribati uses the Australian dollar.

523 Tuvalu Central Statistics Division. GDP 2018. See https://stats.gov.tv/economics/national-accounts/gdp-2018/. Accessed 29/11/2024.

524 Government of Tonga (n.d.). Tonga Statistics Department National Accounts 2020/21. https://tongastats.gov.to/statistics/economics/national-accounts/#74-246-2020-21. Accessed 29/11/2024.

525 Solomon Islands National Statistics Office (SINSO)-GDP 2003-2017, 2023. Statistics Bulletin: 5/2020. Available https://www.statistics.gov.sb/images/SolomonFiles/Economic-Statistics/Gross_Domestic_Product/GDP-2003-2017-Bulletin-5_2020.pdf. Accessed 29/11/2024. Exchange rate of $1 = SI$8.45 used as of 25/03/2024.

Employment

Table 56 shows employment figures in the quarry and mining sector in PICs. However, publicly available statistical data are only available for six of the 14 countries listed. In addition, similar to GDP data, other than in Solomon Islands, the employment data does not differentiate between mining and quarrying and instead combines them. In the case of Kiribati, things are even more complicated given that employment data cover multiple other sectors like electricity, gas, and water supply. It is therefore not possible to determine the specific number of people involved in quarrying, which in this case would be sand mining /dredging.

Other than PNG, most Pacific countries have more quarrying than high-value mining operations. Therefore, it can be inferred that the figures for other countries are indicative of the quarrying sector. However, just like the GDP figures the employment statistics might be falling short of the exact numbers employed in the sector. For example, in 2019 in Samoa, the total workforce in the quarry sector was reported as being just six, and yet a visit to China Harbour's quarry in Apia in December 2023 revealed that there were 15 staff working at this one quarry site alone. It should also be emphasized that employment figures do not include employees involved in the numerous support services for the quarry sector such as mechanics, electricians, transportation companies, equipment suppliers, geologists, environmental consultants and so. Furthermore, employment is also generated in downstream industries, such as the construction sector and agriculture, as well as government agencies that regulate the sector. In short, the employment contribution of the sector is considerably higher than the employment figures reported in official statistics.

Table 56: Quarrying and Mining Employment Statistics

Country	Total Workforce	Year Reported	Sector(s) covered by data
Papua New Guinea[526]	9,011	2011	Mining and quarrying
Solomon Islands	1,017	2012–13	Quarrying
Vanuatu	270[527]	Current	
Kiribati	260	2019[528]	Mining and Quarrying; Electricity, gas, and water supply
Samoa	6	2019	Mining and Quarrying
Tonga	86	2018	Mining and Quarrying
Fiji	2,440	2019	Mining and Quarrying
Cook Islands	25	2019	Mining and Quarrying
Niue	No data		
Federated States of Micronesia	No data		
Republic of Marshall Islands	No data		

[526] Jones, L.T. and McGavin, P.A. (2015). Grappling Afresh with Labour Resource Challenges in Papua New Guinea: A Framework for Moving Forward. Port Moresby: Institute of National Affairs. https://www.inapng.com/pdf_files/Grappling%20afresh%20with%20labour%20resource%20challenges%20in%20Papua%20New%20Guinea%20-%20a%20framework%20for%20moving%20forward-Final(2).pdf. Accessed 25/03/2024.

[527] 270 people is an estimate based on the quarry data obtained from the Department of Geology and Mines. There are 27 commercial quarries in Vanuatu, each is estimated to employ 10 people.

[528] https://sdd.spc.int/digital_library/poverty-kiribati-based-analysis-2019-20-household-income-and-expenditure-survey

Country	Total Workforce	Year Reported	Sector(s) covered by data
Tuvalu	No data		
Nauru	No data		
Palau	No data		

Source: Respective country statistics

In summary, official data on revenue, employment and GDP contributions are very limited in the Pacific Islands and even visits to relevant government departments did not yield the information.

5.3 Occupational health and safety

Quarrying poses numerous health, safety, and welfare risks due to physical and health hazards, which can affect not only employees and contractors but also people in communities surrounding quarry operations and transport routes.[529] OHS in the quarrying industry aims at protecting the physical and mental health of workers and surrounding communities. Hazards include but are not limited to dust pollution (both from crushing operations and haulage trucks), noise, falls, injury from moving vehicles, and the use of explosives, among others. These OHS hazards are outlined in Table 57 below.

Table 57: Potential Occupational Health and Safety Hazards in Quarrying

Health and Safety hazards
Risks of collapse quarry face/rock fall
High number of vehicle movement
Fall from height
Injuries from lifting, carrying, pushing, and pulling heavy loads
Fire and/or explosion (including plant fire, misfire, and fly rock)
Electrocution while working in the electric circuit
Vibration from moving vehicles or working equipment
Cuts/injuries, heat, radiation
Respirable dust exposure (including crystalline silica exposure)
Hearing loss (caused by noise from machinery like grinders and compressors)
Fatigue

source: Safe Quarry Guide, www.hsa.ie

[529] Health and Safety Authority (2019). *Safe Quarry. A Guide for Quarry Workers*. https://www.hsa.ie/eng/publications_and_forms/publications/mines_and_quarries/safe_quarry_-_a_guide_for_quarry_workers.pdf. Accessed 21/11/2023.

To minimize and manage these hazards, quarrying operations should have a well-defined OHS program in place that is followed and enforced by both employer and employee.[530] Good practice OHS includes having the following systems and processes in place:[531]

- Appointing a competent person with sufficient resources to be the operator of the quarry
- Having safe working procedures, a code of practice and other procedural controls
- Carrying out regular risk assessments
- Educating workers on the potential hazards and risks involved in the whole operation and how enforcing control measure will protect their health
- OHS training is key to ensuring a safe and secure quarry working environment[532]
- Provision of medical services such as medical surveillance and rehabilitation after injury or illness
- Effective supervision
- Incident monitoring, reporting and evaluation

This section examines health and safety performance in the quarry sector in PICs, including assessing legislative and regulatory requirements for OHS, evidence of implementation by companies (including the existence of site level QMPs),[533] and OHS performance, as measured by significant incidents reported in official data or by media. As is the case for employment and revenue data, information on OHS is also very limited. Anecdotal evidence acquired from stakeholder consultations suggests that many companies and even government agencies do not have mechanisms in place to collect safety incident data, even if required by regulations.

5.3.1 Fiji

The Quarries Act (Cap 147) is the primary legislation that governs OHS in quarries in Fiji (see Fiji country profile). The act provides for better management of quarries including both worker and public health and safety. To minimize quarry hazards, especially physical hazards, the act outlines specific safety and protection measures, such as fencing, first-aid outfits, safe handling and use of explosives, restricted entry after blasting and safety helmets.[534] It was noted during the 2018 Baseline Assessment that the safety in hard rock quarries was majorly enhanced by the standards of explosive suppliers, with the supplier ensures strict adherence to the safety standards before he can supply explosives to the quarry operators.[540]

[530] Bo, M., Fargione, P., Maida, L., & Pognant, F. (2017). Occupational Safety and Health and Environmental Safety criticalities depending on geo-economic areas: a focus on mining and quarrying activities. In *Prevention of Accidents at Work* (pp. 271-278). CRC Press; Aspirtakis, I., & Galetakis, M. (n.d). Health and Safety Management in Quarries Industry. Ergoprolipsis-Health and Safety Services, Greece; Health and Safety Authority (2020). Safety, Health, and Welfare at Work (Quarries) Regulations 2008. safe_quarry_regs_2020.pdf (hsa.ie).

[531] AggNet (2003). Health and Safety in Quarrying. https://agg-net.com/resources/articles/health-safety/health-and-safety-in-quarrying-3

[532] Training needs assessment identifies the safety and heath training needs for all workers based on safety and health related roles and responsibilities.

[533] Training represents a good opportunity for quarry employees to grow their knowledge base and improve their OHS skills (awareness) to become more safety cautious in the workplace. The training can be onsite (workers trained at the job site) or offsite (conducted in a separate place, e.g., education institutions or training centers). To ensure continued good safety practices, the safety managers should design safety training needs assessment and refresher courses for all the workers. Quarry Management Plan means the plan prepared by the quarry owner/operator and approved by a delegated authority governing the site specific development of an area for the purpose of extracting materials, the methods for the extraction, the volume of materials to be extracted and the means for rehabilitating or restoring the site.

[534] Quarries Act 1939 (as amended 1969).

The Health and Safety at Work Act 1996 which reforms the law relating to the health and safety of workers and other people at work or affected by the work of other people also applies to quarries.[535] However, the regulation of the mining and quarry industries is not covered by the Health and Safety at Work Act due to the industry-specific risks associated with the sector.[536]

There have been several safety incidents in quarries in recent years, both fatalities and injuries. For example, the 2018 Baseline Assessment of Development Minerals in Fiji ascertained that there were 286 cases (as reported by the Ministry of Employment-Workers Compensation Unit) between 2007 to 2017.

There have also been recent fatalities in the quarry sector. For example, on 20 March 2020 at the Mau quarry in Namosi three people lost their lives due to a landslide during heavy rain.[537] In April 2023, there was another incident where a digger operator died at a gravel extraction site in Waiyanitu, Navua. The residents around Navua also expressed concern over the increasing dust, and associated health risks, emanating from trucks ferrying gravel for construction projects in Suva. Some Landowners also claimed that the contractors have not carried out a proper EIA.[538]

As noted earlier, to combat such incidences, the workers need to be trained in safe quarry practices and there should be community awareness of the potential health and safety issues that may arise from the quarry operations. Fiji National University offers a certificate course in OHS covering various industries, including mining and quarrying.[539] In addition, in 2019, UNDP through the ACP-EU-Development Minerals Programme conducted OHS training for 27 quarry workers and quarry operators.[540]

5.3.2 Vanuatu

Occupational health and safety in quarries in Vanuatu is governed by the Quarry Act 2013,[541] while general health and safety at the workplace is legislated by the Health and Safety Act Cap 195. The act stipulates the duties of both workers and employers regarding safety and health in the workplace. Under the act, employers are responsible for providing a safe working environment for employees and, in return, all employees are required to follow safe working procedures and use appropriate protective equipment when necessary.

In addition, the PWD Quarry Guide stipulates that any contractor operating a quarry must provide a quarry management plan that includes a health and safety plan though details of what should go in this plan are not explained.[542]

535 Health and Safety at Work Act 1996.

536 Papua New Guinea Mine Watch (2016). Mine Workers in Fiji Not Covered by Health and Safety Laws. 26 November. https://ramumine.wordpress.com/2016/11/30/mine-workers-in-fiji-not-covered-by-occupational-health-and-safety-laws/. Accessed 23/10/2023.

537 Vakasukawaqa, A. (2020). Buried alive: 2 dead and one missing in quarry tragedy. The Fiji Times, 21 March. https://www.fijitimes.com/buried-alive-2-dead-and-one-missing-in-quarry-tragedy/. Accessed 21/11/2023.

538 Kumar, R. (2023). Digger operator dies. The Fiji Times. 1 April. https://www.pressreader.com/fiji/the-fiji-times/20230401/281633899500922. Accessed 21/11/2023.

539 Fiji National University study programs. https://www.fnu.ac.fj/study/program/?program=320.

540 UNDP Fiji, 2018. ACP-EU Development Minerals Programme. Fiji Training of Trainers (ToT) Workshop on Occupational, Health and Safety in Quarries: http://www.developmentminerals.org/index.php/en/training/events/18-country-training/303-fiji-training-of-trainers-tot-workshop-on-occupational-health-and-safety-in-quarries-2.

541 Food and Agriculture Organization of the United Nations. The Quarry Act 2013. https://faolex.fao.org/docs/pdf/van150061.pdf.

542 Vanuatu PWD Quarry Guide, 2014. https://pwd.gov.vu/images/PWD_Documents/Policy_and_Strategy/PWD_Quarry_Guide_booklet_Final_Version_-With_Cover.pdf.

Like many PICs, with no official reporting of safety incidents, or even formal collection of data, assessing the OHS performance in the Vanuatu quarry sector is challenging. The best that can be said is that there have been no media or government reports in recent years of any fatalities or major incidents in the sector.

5.3.3 Solomon Islands

OHS in Solomon Islands is regulated by the Occupational Safety and Health Act 2002 and the Safety at Work Act 1982. These acts promote and protect the health, safety, and welfare of people at work. The acts stipulate that the employer has an overall responsibility for ensuring compliance with OHS regulations in the workplace. The act also stipulates that every operation should set out an OHS policy that will be specific to the nature and size of the operation.[543]

In terms of safety performance, the Solomon Islands National Minerals Policy 2017–2021 acknowledges the poor track record of workplace health and safety in the mine and quarry industry. Most safety standards at mine/quarry sites have been self-regulated by the operators/companies as there has been no national standard or compliance requirement. However, the policy aims to ensure that appropriate health and safety standards and procedures are put in place at every workplace including quarry sites.[544]

5.3.4 Tonga

According to the International Labour Organization, Tonga is one of the Pacific countries that is in the process of drafting its OHS legislation.[545] The Employment Relations Bill 2020 was passed into law in 2020. Part XIII of the act requires the employer to provide a safe working environment and, at the same time, the employee to exercise a high standard of care for his/her own health and safety.[546] Tonga places a high priority on worker and community health and safety in the work environment including quarrying activities. For example, under section 76 of the Employment Relation Bill 2020, the government proposes to provide for training of workers in order to reduce hazards and improve safety in the workplace.[547]

5.3.5 Samoa

The Samoa Occupational Safety and Health Act 2002 stipulates that every workplace will ensure a safe and healthy environment for the workers. The act aims at enhancing the productivity, safety, health, and welfare of workers as well as protecting the neighboring community from risks to safety that may emanate from the activities of the workplace.

There have been several incidents in the past, including fatalities. For example, in September 2018, there was a landslide that killed three people and injured two others. It was ascertained that the

[543] Occupational Health and Safety, Labour Divison, MCILI, Solomon Islands.

[544] National Minerals Policy 2017–2021. Ministry of Mines, Energy and Rural Electrification, Solomon Islands. Available https://solomons.gov.sb/wp-content/uploads/2020/02/National-Minerals-Policy.pdf. Accessed 01/12/2023.

[545] International Labour Organization (n.d.). Safety and Health at Work in Pacific Island Countries. https://www.ilo.org/suva/areas-of-work/safety-and-health-at-work/lang--en/index.htm.

[546] Employment Relations Bill 2020-Tonga

[547] Shelter Cluster (2021). Local Building Cultures for Sustainable and Resilient Habitats.

https://sheltercluster.org/promoting-safer-building-working-group/documents/tonga-detail-shelter-response-profile-local.

quarry owner did not have a permit to operate the quarry.[548] This illustrates the importance of the government having the resources and capacity to enforce regulations in the sector and to take action when operators are operating outside of the law.

Anyone who intends to open and operate a quarry is required to prepare and submit a health and safety plan, which is integral to the required environmental and social management plan.[549] The health and safety plan must outline the safest way to operate the quarry including transportation of materials, equipment, and plant.

According to the 2019 labor market survey, mining and quarrying was the only sector that complied with the OHS evacuation guidelines.[550]

5.3.6 Papua New Guinea

OHS in workplace environments including quarries is regulated by the Occupational Health, Safety and Welfare Act 1991 and the Mining (Safety) Regulations 1935. The act aims at securing the health, safety, and welfare of the workers by having a secure work environment.

While safety performance is well monitored in PNG's large-scale mining sector by the Mineral Resources Authority (MRA),[551] this does not appear to be the case in the quarry sector. As in many other countries in the region, safety performance data in the quarry sector are not publicly disclosed, which limits assessment to incidents and other indicators of safety performance covered by the media, though these do not always pick up all incidents. One high-profile safety disaster occurred in January 2012, when at least 27 people were killed when the Tumbi limestone quarry in the Southern Highlands operated by Esso Highland Limited, a subsidiary of Exxon Mobile collapsed. The cause of the quarry landslide was due to the improper quarrying practice.[552] Tumbi quarry was also a source of aggregates used to construct various projects in the neighboring areas.[553]

5.3.7 Tuvalu

Occupational health and safety at the workplace in Tuvalu is regulated through the Employment Act 2008. Under this act, the employer is required to inform the commissioner or Health Officer in the event that the employer believes that a defect in a plant, working methods, supervision, or layout might constitute a threat to the health or safety of the worker. However, there are no official statistics on OHS in Tuvalu.

5.3.8 Kiribati

The newly established OHS unit under the Ministry of Employment and Human Resources is responsible for matters related to the health, safety, and welfare of workers at the workplace.

548 RNZ (2018). Developers of Samoa Quarry Where 3 Died Did Not Have Permit. 21 September. https://www.rnz.co.nz/international/pacific-news/366947/developers-of-samoa-quarry-where-3-died-did-not-have-permit.

549 Ministry of Works, Transport, and Infrastructure. https://www.mwti.gov.ws/wp-content/uploads/2022/02/Samoa-SARIP-ESMF-Final_Jan2022.pdf.

550 Samoa Labour Market Survey (2019). https://www.mcil.gov.ws/wp-content/uploads/2020/08/LMS-2019_28JUL2020_Lite-Version-FINAL-1.pdf.

551 For example, the MRA which regulates the mining industry publishes a Mining Industry Quarterly OHS Bulletin.

552 Shearn, I.T. (2014). Exxon's New Guinea Nightmare. Type Investigations. 1 May. https://www.typeinvestigations.org/investigation/2014/05/01/exxons-new-guinea-nightmare/. Accessed 01/12/2023.

553 Petley, D. (2012). An Update on the Tumbi Quarry (Papua New Guinea) Landslide. https://blogs.agu.org/landslideblog/2012/01/31/an-update-on-the-tumbi-quarry-papua-new-guinea-landslide/. Accessed 01/12/2023.

This unit was established based on the Occupational Health and Safety Act 2015.[554] The core objectives of the OHS unit include:

- Carry out OHS inspection of all workplaces to ensure compliance with the OHS law
- Promote OHS awareness and education to the public and workplaces on rights and obligations relating to the OHS law
- Provide advice and guidance where required to workplaces on formulating OHS policy and related matters
- Assist workplaces in the establishment of OHS committees or OHS representatives to fulfil obligations under the OHS Act
- Establish connections with relevant authorities including International Labour Organization technical expertise to identify or advise on specific unknown substances or hazards such as chemicals, etc.

There are also no official statistics that exist for OHS in Kiribati.

5.3.9 Niue

The Constitution of Niue under the Public Service Regulations, Part 13 stipulates that the public service commission must take all practical steps to ensure and promote the safety and health of workers in the workplace by taking the following measures:

- providing and maintaining a safe and healthy work environment
- providing and maintaining facilities for safety and health
- providing safety and health awareness education, and
- developing procedures for dealing with emergencies

There is no specific law that addresses OHS at quarry sites in Niue and no safety reporting to the government.

5.3.10 Nauru

There is very limited information on OHS in the quarry and mining sectors in Nauru. OHS in the workplace (especially in the public sector) is supposed to be enforced by the Department of Human Resources and Labour. However, a 2022 US Human Rights report on Nauru reported that the government sets some OHS standards, but enforcement is poor.[555] The private sector also has poor standards and compliance.[555]

5.3.11 Cook Islands

There is no specific law on OHS in the Cook Islands; however, the government was to implement workplace health and safety reforms in 2020[556] to provide more protection for workers. The reforms focus on putting forward policies for the regulation of workplace health and safety, which in turn will support the enactment of a Workplace Health and Safety Law.[557] Again, there does not appear to be any reporting of safety performance data.

[554] Government of Kiribati. Occupational Health and Safety Act 2015. https://www.employment.gov.ki/labour-division/occupational-health-safety-osh-unit/occupational-health-safety-act-2015. Accessed 01/12/2023.

[555] U.S. Department of State (2023). Nauru 2022 Human Rights Report. www.state.gov/wp-content/uploads/2023/03/415610_NAURU-2022-HUMAN-RIGHTS-REPORT.pdf. Accessed 01/12/2023.

[556] Workplace Health and Safety Workers Compensation. https://www.intaff.gov.ck/labour/workplace-health-and-safety-workers-compensation/. Accessed 01/12/2023.

[557] Ibid.

5.3.12 Federated State of Micronesia

OHS in the FSM is regulated by the Occupational Safety and Health Act 2000. However, there is no information on OHS in quarries in the FSM, nor any publicly disclosed safety performance data.

5.3.13 Republic of Marshall Islands

There is no information on OHS in dredging or sand mining / quarrying in the RMI. However, OHS in the general workplace environment is regulated by the Occupational and Health Act 1998. Although the act provides for procedures and mechanisms for a safe working environment, there is no evidence of enforcement to ensure good practice is followed.[558]

5.3.14 Palau

Palau is one of the Pacific countries in the process of drafting its OHS legislation. However, there is an established International Standards Organization center in Palau that conducts the foundation training in the ISO 18001 OHS course which covers policies, risk assessment, and health hazard prevention.[559] However, due to the lack of performance data, it is difficult to ascertain whether it is improving performance in the quarry sector.[560]

In conclusion, some countries such as Fiji, PNG, Samoa, Solomon Islands, and Vanuatu have national OHS legislation, while the rest are in the process of formulating and finalizing it. However, apart from Fiji and Vanuatu, which have dedicated Quarry Acts, the rest rely on general OHS legislation to ensure a safe working environment in quarries.

However, despite this there is little, and in many cases, no data on such issues as the incident statistics in quarries and other aggregate extraction activities.

6. Good Practice Principles for Responsible Sourcing of Aggregates in the Pacific

Overview

The principles presented in this section aim to encourage and support the responsible sourcing of aggregates in PICs. The principles respond to concerns among donors, Pacific Island governments, communities, and others that the sourcing of aggregate for infrastructure projects in the Pacific Islands often comes at a significant environmental, social, and economic cost, as described in the previous section.

[558] U.S Department of State (2022). Country Report on Human Rights Practices: Marshall Islands. https://www.state.gov/reports/2022-country-reports-on-human-rights-practices/marshall-islands.

[559] The Knowledge Academy. ISO 18001 Foundation Overview. https://www.theknowledgeacademy.com/pw/courses/iso-18001-training/iso-18001-foundation-/palau/. Accessed 01/12/2023.

[560] The only information on safety incidents in Palau's quarries was reports of a PRC man died when he was caught up in a conveyor at Palau National Quarry in Ngeremlengui in 2017. See https://www.facebook.com/ThinkBigPalau/posts/island-times-man-dies-after-getting-caught-in-conveyor-beltbyadmin-june-27-2017-/1739104402796655/.

Environmental concerns include poorly regulated river gravel and sand extraction which, among other things, can damage aquatic ecology, affect drinking water, erode river banks, reduce vegetation and biodiversity, and exacerbate flooding;[561] beach sand mining, which can exacerbate coastal erosion and lead to the loss of coastal protection against extreme weather events; and the blasting of coral reefs. Social concerns include poor OHS practices at quarry sites with high injury and fatality rates, land disputes, disrupted river navigation, or decreased fish stocks and food security due to sedimentation caused by river extraction. Meanwhile, economic impacts can include damage to coastal infrastructure from sand mining and even loss of coral reef and beaches, resulting in loss of fisheries and tourism.

The principles draw on examples of international good practice and regionally specific guidelines, as well as insights from key stakeholders, to provide guidance on the responsible sourcing of aggregates for the infrastructure sector. This section is organized as follows: first, it provides a set of general principles applicable to all types of aggregate operations, encompassing both environmental and socioeconomic issues. Next, it presents principles specific to each of the main types of aggregate operations in the Pacific Islands, namely: river gravel and sand operations; beach sand mining; lagoon dredging and coral reef mining; and hard rock quarries. Finally, principles have also been developed for governments seeking to improve responsible aggregate sourcing.

The principles are written primarily for infrastructure donors and contractors, extraction companies, and government agencies with a role in implementing, regulating or funding aggregate extraction activities. However, they are also for all stakeholders who may be impacted or have an interest in aggregate extraction operations in PICs.

When applying the principles, users need to balance the aspirational aims outlined in this document with the practical realities of sourcing materials for what may be infrastructure projects of national significance. In some cases, alternative materials may not be available at a price and in a timeframe that is feasible. In such cases, contractors will need to work with suppliers and government to improve extraction practices and ensure a responsible outcome.

Key definitions

Contractor: Firms involved in construction activities. Contractors may also own or operate their own quarries or other extraction operations.

Operator: Company directly involved in aggregate extraction operations, including quarries, river gravel and sand operations and dredging activities.

Supplier: Provider of aggregates to construction contractors. Suppliers can be either a quarry / extractive site operator or a third party that buys from an operator and sells to the contractor.

[561] Taga, R. & Smith, R. (2021). *A River Gravel and Sand Extraction Guideline 2021*. Compiled by Dr Raijeli Taga and Robert Smith. Fiji Ministry of Lands and Mineral Resources. Development Minerals Technical Working Committee. In review.

Principle	Description
GENERAL GUIDING PRINCIPLES	
1. Contractors must develop an aggregate extraction plan as part of the infrastructure tender process	• All contractors for donor-funded infrastructure projects must develop and submit for review an aggregate extraction plan that identifies each source of aggregate to be used and how it will ensure the general guiding principles outlined in this guidance document will be adhered to. • Where certain principles are not, or cannot, be followed, contractors should provide an explanation. Cost considerations alone are insufficient justification, unless the inability to follow a principle(s) can be proven to not be relevant or to make material costs prohibitive.
2. Ensure aggregate to be sourced meets quality standards required for the project	• Particularly in the case of river gravel and coronus materials from soft rock quarries, contractors should undertake testing in accredited laboratories to ensure aggregate material meets quality standards required for the project.
3. Use local materials where possible	• Bearing in mind prohibitions on the use of local aggregates by some donors in countries like the Marshall Islands, aggregate extraction sites should be located near the project or place where materials will be used provided resources exist, quality specifications are met, and it is economically feasible. • Use of local materials stimulates local employment and business opportunities. In addition, less distance travelled from the quarry to the construction site/point of use leads to a reduction of transportation footprint. Aggregates have a high bulk value, but low unit value, with transportation costs representing about 60% of the delivered cost.
Environment	
4. Aggregate extraction sites should have all required permits and approvals from the relevant authorities	• Without these permits and approvals, contractors should not source aggregates from these sites.

	• Contractors and, where relevant, infrastructure project donors, should undertake compliance checks to ensure that all approvals and permits, including environmental approvals, have been obtained and are current.
5. Ensure operations comply with a country's environmental regulations and policies, including the conduct of Environmental Impact Assessments (EIAs) and development of Environment Management Plans	• Following on from Environmental Principle 1 above, suppliers should comply with EIA regulatory requirements in each country; where these do not exist suppliers should look to refer to good practice in other Pacific Island countries (PICs) or international standards, such as the Asian Development Bank's EIA requirements.[562] EIAs should include baseline data on key environmental and social parameters. • Even where not explicitly required by regulation, extractive site operators should incorporate social issues, such as impacts on community health and safety, impacts on livelihoods and so on into EIA processes and develop appropriate management plans to address risks and opportunities.
6. Avoid extraction in areas identified as being of conservation importance	• Aggregate sourced from any areas identified as being part of a protected area / proposed protected area, or having conservation importance should not be used in infrastructure projects. Likewise, donors should not support projects if aggregates are to be sourced from these areas.
7. Ensure rehabilitation of extractive sites is done in accordance with regulatory requirements	• Operators of extraction sites must rehabilitate sites in accordance with the requirements of permits issued by relevant agencies. At a minimum, all areas that were disturbed by the extractive operations should be stabilized so that accelerated erosion and / or sedimentation will be prevented. • In the case of sites opened specifically for donor-funded infrastructure projects, donors should inspect sites within the period specified under permits to ensure rehabilitation has been completed satisfactorily.
8. Ensure export / import of aggregates between countries does not pose a biosecurity risk	• The import of aggregate materials across international boundaries poses a risk of introducing biohazards / pests that can have adverse environmental, economic, and social impacts in the countries of importation. To ensure these risks are managed, aggregate suppliers should provide evidence that shipments are inspected and fumigated

[562] See ADB's Safeguard Policies (2009) or equivalent policy, e.g., World Bank's Environmental and Social Safeguards. See https://www.worldbank.org/en/projects-operations/environmental-and-social-policies

	for pests prior to shipping. Contractors should be responsible for ensuring compliance with this rule.
9. Establish and implement an environmental monitoring, evaluation and reporting system	• Effective monitoring, evaluation, and reporting of aggregate extraction operations is key to ensuring environment management plans is adhered to and the environmental conditions set out in permits are being complied with.
Socioeconomic	
10. Engage meaningfully with stakeholders in the vicinity of aggregate extraction sites	• Ensure that all stakeholders with an interest in the aggregate extraction activities are meaningfully engaged prior to and during operations to seek their input into the design and ongoing operation of sites. Particular emphasis should be placed on landowners and local communities in the vicinity of operations.[563] • Engagement should be two way, participatory, and inclusive of women, youth, indigenous peoples and other disadvantaged groups in project communities. Specific measures should be designed and implemented to ensure such groups are included.
11. Obtain the consent of local communities and other rights holders before commencing activities on their lands or marine resource areas	• Prior to establishing aggregate extraction activities, operations must identify the landowners / resource rights holders and obtain their consent to conduct extractive operations. This should culminate in a memorandum of understanding and / or other legal agreement, depending on local regulatory requirements. • Where consent cannot be obtained, operations should not proceed. • Commencing operations on sites which have been acquired by government under compulsory acquisition laws and involving land resettlement should only be considered as a last resort and where failure to obtain materials will significantly jeopardize a project.

[563] For good practice, see OECD (2017). OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector. https://www.oecd.org/publications/oecd-due-diligence-guidance-for-meaningful-stakeholder-engagement-in-the-extractive-sector-9789264252462-en.htm.

12. Ensure fair compensation to landowners / resource owners	• Contractors should submit evidence to donors on a twice yearly basis that payment of royalties to landowners/resource owners and government has been done in compliance with regulation. This evidence should be obtained from the supplier.
13. Establish a mechanism for communities and employees to report concerns and grievances	• Operators of extractive sites should establish a mechanism by which employees or members of the public can report concerns and grievances about aggregate operations to the operator. • The grievance mechanism should be clearly visible to members of the public, allow for anonymous reports to be made, and information about it provided in an easily understandable format. • The grievance mechanism should be regularly monitored, complaints acted upon, and actions taken should be publicly disclosed to employees and affected local communities.
14. Implement good practice occupational health and safety (OHS) systems	• Operators should implement good practice OHS at sites, as required under the country's regulations.[564] • Lessons and insights on successful implementation can also be incorporated from other PICs where required.
15. Avoid risks to community health and safety	• Site operators should ensure good practice measures are in place to avoid all foreseeable risks to community health and safety. Priority issues include traffic management, blasting, dust, noise, and pollution, particularly in waterways.
16. Engage with local people to determine opportunities for employment and business development	• Where possible, contractors and project donors should engage with site operators to ensure employment and business development opportunities are provided to people in communities surrounding extractive sites. • This could involve provision of small loans to start business, training and other knowledge transfer activities such as in the areas of machinery and plant maintenance and / or operation.
17. Avoid impacts to archaeological and historic sites	• While they should be addressed through a country's EIA processes, contractors should remain vigilant about potential of impacts on significant archaeological and historical sites

[564] See for example, NSW Resources Regulator (2018). Health and Safety at Quarries. November. https://www.resourcesregulator.nsw.gov.au/sites/default/files/documents/nsw-resources-regulator-mines-and-quarries-book-complete-v6.pdf. Accessed 13/12/2023.

	when sourcing aggregates. Where these impacts have not be managed to the satisfaction of land / resource owners and other key stakeholders, contractors avoid sourcing from the sites concerned.
GUIDING PRINCIPLES FOR RIVER EXTRACTION	
1. Aggregate from hard rock quarries should be prioritized over aggregate from rivers	• Extraction of sand and gravel from rivers often has adverse impacts on the environment and surrounding communities, including siltation, increased flooding, damage to coral reefs, loss of fisheries, and even impacts on the ability of households to source clean water for basic needs. Extraction from upland sections of rivers can be especially damaging. • Where alternative sources of aggregate exist (i.e., hard rock quarries) contractors should, in the first instance, source from them. • Exceptions to this principle are cases where river extraction does not exceed natural recharge rates and can be undertaken sustainably, as determined through scientific methods. • Governments are encouraged to develop a network of hard rock quarries as a source of aggregate.
2. Ensure sustainable river gravel and sand extraction levels	• The quantity of gravel/sand extracted should not be greater than the rate of natural replenishment. River bed loads can be determined through recognized scientific methodology, such as doing cross sections of rivers via hydrographic mapping methods.[565]
3. Extraction must be done in a way that it maintains the river's flood flow capacity	• Extraction should be planned and implemented with the objective of improving river flood flow capacity. • This involves determining the minimum and maximum extraction levels since over-extraction can reduce the river bed level leading to problems of channel widening, bank erosion and channel change. Conversely, under-extraction may result in aggradation of

[565] Taga, R. and Smith, R. (2021). A River Gravel and Sand Extraction Guideline. Development Minerals Technical Working Committee, Fiji Ministry of Lands and Mineral Resources.

	the riverbed which decreases the ability of the river channel to carry floods and increases sedimentation in river estuaries that often restrict navigation.[566] • Operators should conduct operations in a way that does not disturb riverbank vegetation or integrity.
4. River gravel and sand extraction should not interfere with activities on the surface of rivers	• Activities such as transportation for goods and people, and recreational and tourism activities may be adversely impacted by river gravel and sand extraction. This can be due to the creation of wide, shallow water channels, siltation, presence of machinery in water and other factors. • When sourcing from rivers, contractors should ensure that operators put in place measures to ensure such impacts are avoided or mitigated.
5. Avoid discharge of sediments and pollutants into rivers	• When planning extraction activities, operators should put in place measures to avoid run-off of sediment and pollutants into rivers, streams, and other water bodies. • Measures can include maintaining a set distance between the works site and water bodies so as to reduce the likelihood of accidental discharges; placing rocks or other structures to minimize discharge of sediment into rivers, building channels to direct storm water from the site to avoid spreading of contaminants and sediment, building bunds to isolate refueling areas, and proper storage and maintenance of machinery to avoid oil and chemical spillage.[567]
6. Assess whether multiple extractive sites in one catchment are likely to have adverse cumulative impacts	• Contractors should determine whether sourcing materials from a river where there are other extractive operations is likely to have adverse cumulative environmental and social impacts. If so, material should not be sourced from multiple sites by operators in the catchment, unless there is evidence these are being managed appropriately.
7. Minimize in-river works	• To prevent deterioration in water quality, operators should keep machinery out of water unless it is necessary for critical works or access to the work site.[568] • River extraction should be avoided during fish spawning and migration periods.

[566] Taga, R. and Smith, R. (2021). A River Gravel and Sand Extraction Guideline. Development Minerals Technical Working Committee, Fiji Ministry of Lands and Mineral Resources.

[567] Government of the Solomon Islands and Cardno (2012). Solomon Islands Road Improvement (Sector) Project: Guidelines for Sourcing Road Construction Materials.

[568] Ibid.

8. Collect baseline data on water quality and sedimentation	• Operators must be able to show that they have collected baseline data on water quality and sedimentation using good practice scientific methods, whether required by regulation or not, prior to agreeing to purchase river gravel and sand. • Contractors should review the results of ongoing monitoring and evaluation. Where there is evidence of a deterioration in water quality linked to operations, contractors should work with operators to manage the key causes of sedimentation and pollution impacting water quality.
GUIDING PRINCIPLES FOR SAND MINING AND LAGOON DREDGING (IN ATOLL SETTINGS)	
1. Sand mined from beaches and nearshore areas should not be used in donor-funded infrastructure projects.	• Large scale commercial mining of sand from beaches and nearshore areas (not including river mouths and estuaries) has significant negative environmental and economic impacts in the Pacific Islands. These include accelerated shoreline erosion, loss of coastal protection, loss of amenity and increased risk of damage to coastal infrastructure from extreme weather events. • Alternative sources of sand should be explored, including sustainably sourced lagoon aggregate. Experience from the Environmentally Safe Aggregate for Tarawa project in Kiribati demonstrate that atoll countries do have significant sand, gravel and stone resources in lagoon areas which can be sustainably harvested for aggregates.
2. Aggregate excavated from coral reefs, including through blasting, should not be used in donor-funded infrastructure projects	• A lack of aggregate resources has led to the excavation of coral reefs, including through blasting, in some PICs. This should be avoided at all costs in donor-funded infrastructure project. • Alternative sources of sand should be explored, including sustainably source lagoon aggregate.
3. Undertake socioeconomic studies to understand how prohibitions on beach and reef mining will impact local people, including women and vulnerable groups	• Where beach and coastal sand mining is prohibited, contractors and donors should commission studies to understand how prohibitions on sand mining will impact the livelihoods of those who rely in small-scale sand mining as a key source of income. These studies should pay particular attention to women and vulnerable groups in communities who may be most affected.
4. Provide employment and other economic opportunities for small-scale sand miners	• To compensate for the loss of sand mining income, small-scale sand miners should be offered employment in lagoon extraction operations, including on dredgers and at beneficiation sites on shore.

	• Longer term, sand miners should be supported through training to transition to other economic and employment opportunities
GUIDING PRINCIPLES FOR HARD AND SOFT ROCK QUARRYING	
1. Quarry sites should be planned in a way that provides a physical buffer for surrounding communities	• To avoid undesirable impacts on local communities (e.g., noise, dust, traffic, etc.), contractors should submit a plan for new quarry development as part of the project tender process. Wherever possible, these plans should ensure that quarry boundaries come no closer than 500 m from cities / towns / villages, and no closer than 300 m of the nearest dwelling.[569] • As far as possible, the quarry should be screened from public view by using the existing topography and trees.
2. Develop a Quarry and Environmental Management Plan (QEMP)	• Quarry operators should submit a QEMP for review by the relevant government authority(s) responsible for regulating quarries. • The QEMP should describe all operational aspects of the quarry, from the location of aggregate stockpiles and equipment to OHS, rehabilitation, and community health and safety systems and procedures. Reference should be made to good practice QMPs / QEMPs and guidance.[570]
3. Ensure proper benching	• Quarrying should be undertaken through a series of working benches, rather creating vertical faces. These are considerably safer because they reduce the chance of landslides and are also easier to rehabilitate.
4. Ensure any blasting does not pose a danger to life or property	• Blasting (if required) must be carried out in a manner that does not endanger life or property. Quarry operators should follow local laws and where these are lacking, international good practice guidance should be followed.[571]

[569] Government of the Solomon Islands and Cardno (2012). Solomon Islands Road Improvement (Sector) Project: Guidelines for Sourcing Road Construction Materials.

[570] Environment Protection Authority Tasmania (2017). *Quarry Code of Practice, 3rd Edition*. https://epa.tas.gov.au/Documents/Quarry%20Code%20of%20Practice%20May%202017%20-%20web.pdf. Accessed 10/12/2023.

[571] Ibid.

	• A blasting manual should be prepared for the site and, among other things, should include procedures for creating buffer zones from the quarry/blasting zone.
5. Ensure risks of quarry related traffic and dust are well managed	• Quarry operations can pose a risk to communities in several ways, including excessive dust levels, pollution of waterways and, particularly, increased traffic of heavy vehicles. • As part of the site's QEMP, it is essential that adequate procedures be put in place to suppress dust (particularly from crushing and vehicles) and manage traffic so that any safety risks to the public and employees are minimized.
6. Plan for quarry site rehabilitation and restoration as early as possible	• Planning for successful quarry rehabilitation, involving measures outlined in the QEMP, should begin at the earliest stages of quarry development. For larger quarries, a quarry closure plan may also be required.[572] • Planning for successful rehabilitation should include consideration of what the post quarry landscape will be used for (e.g., whether for industry, agriculture, settlement, recreation, etc.). • Overburden stripped during excavation should be stockpiled so that it can be used for land restoration. • Progressive rehabilitation should commence while the quarry is still operating.
SPECIFIC GUIDANCE FOR GOVERNMENT	
1. Develop and publish a Quarry Guide outlining regulatory obligations for operators	• Agencies responsible for regulating aggregate operations should develop a comprehensive quarry guide to ensure operators understand their rights and obligations. • Where these already exist, greater resources, including training need to be dedicated to enforcement, perhaps with the support of international donors and other organizations (e.g., the Pacific Community)
2. Government should prohibit beach and nearshore sand mining, as well as blasting of coral reefs	• This is necessary to mitigate the often significant adverse environmental and socio-economic impacts of these activities.

[572] Ibid.

3. A "whole of government approach"' to the regulation of the aggregates sector is needed	• Effective regulation of the aggregates sector requires all relevant government agencies to work in a coordinated manner to ensure reliable supplies of responsibly sourced aggregates. Government should consider establishing a technical committee modelled on the Development Minerals Technical Committee in Fiji. • Data collected by different government agencies on licensed operations should be shared to create a central repository of information. This will enable better coordination in quarry management, revenue collection, safety compliance and environmental management.
4. Transition from river extraction to a network of hard rock quarries	• Where resources are available, governments should move away from river gravel and sand extraction and work towards establishing a network of hard rock quarries as a source of aggregate.
5. Establish legislation to regulation use of explosives in quarries	• Several PICs do not have legislation to regulate blasting on quarry sites. This, along with training a skilled workforce, is needed to ensure employee and community health and safety is protected.
6. Improve monitoring, evaluation, and compliance with the requirements of legislation, including EIAs	• In most PICs, regulatory systems such as EIAs exist; however, many governments lack the financial and human resources to effectively monitor, evaluate and enforce compliance. • Governments should seek to improve compliance with regulation. Where resources are lacking, they should approach international donors to seek support, either financial and / or in the area of training and knowledge transfer.

7. Conclusions and Recommendations

7.1 Conclusions

ADB has estimated that over $30 billion needs to be invested in PIC infrastructure by 2030. To achieve this will require very large quantities of building materials, including cement, aggregates, and concrete, much of which the region is not currently able to supply.[573] Furthermore, significant environmental and social impacts associated with aggregate extraction in several countries in the region over the past few decades highlight the fact that these materials must be sourced in a sustainable and responsible manner to protect the environment, economy, and people's livelihoods. River gravel extraction, even in countries such as Fiji—the regional hub of aggregate supply—are often unsustainable, as also appears to be the case with operations in the Honiara catchment of Solomon Islands.

The atoll countries have been especially impacted by unsustainable sand mining for several decades though the commencement of projects such as ESAT in Kiribati and TCAP in Tuvalu appear to be delivering sustainable solutions to the significant aggregate challenges in these counties. Sand and coral mining are a problem in certain states of the FSM, such as Yap. Even in Tonga, where beach sand mining has been banned, unregulated extraction continues and has degraded beaches and impacted coastal housing and infrastructure. The way in which some of Tonga's estimated 10 limestone quarries are operated also poses a threat to groundwater and, in many quarries, the quality of aggregate is substandard. With numerous large infrastructure projects planned for PICs in the coming years, providing the right support and policies is critical. One way in which this study aims to address this challenge is by developing a set of Good Practice Principles for Responsible Sourcing of Aggregate in the Pacific.

Based on the information collected during the limited period of this study, the report finds that the ability of some PICs to supply these aggregates is significantly limited and, unless appropriate measures are put in place, there is a risk that some infrastructure projects will be delayed, overbudget, or, potentially, not implemented. This is summarized in Table 58, which provides a preliminary assessment of aggregate self-sufficiency for each of the 14 PRIF member countries.

Table 58: Preliminary Assessment of Aggregate Demand and Self-Sufficiency for Future Infrastructure Project Development

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
The Cook Islands	**High** ~$488 million (NZ$687 million)[574] in projects identified in 2021 national infrastructure plan, with big ticket items	- Volcanic rock / gravel - Limestone rock (coronus) - Sand (inland quarries) - Coastal sand / gravel - Lagoon sand / gravel (potential but sensitive	**Medium** 2020–2022 imports: ~50.3 tons 2020–2022 exports: 0

[573] DFAT (2018). AIFFP Design Document. https://www.aiffp.gov.au/documentation. Accessed 01/10/2023.

[574] Values in New Zealand dollars converted using a 2021 yearly average exchange rate of NZ$1= $0.71.

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	requiring large volumes of aggregate for construction of civil buildings, runways, wharfs, sanitation etc.	environment and currently no extraction)	Several of the islands are well endowed with volcanic and limestone rock, as well as inland sand deposits (e.g., Aitutaki). However, quality is variable. Relatively small quantities of aggregate (~50.3 tons imported 2020–2022) indicating reasonable level of self-sufficiency.
Federated States of Micronesia	**High** Very large infrastructure pipeline in the order of more than $1 billion in the 10-year period leading up to 2025. It is not clear how much of this pipeline has been implemented. Projects identified by PRIF are also significant (~$118 million).	- Volcanic rock (basalt) (Chuuk and Pohnpei only) - Limited sand and gravel - Very small limestone deposits (Yap) - Lagoon / coastal sand (Pohnpei)	**Low-medium** 2020–2022 imports: ~2 tons 2020–2022 exports: 0 Yap - resource poor in terms of high-grade aggregate. There are rivers but resource quantity appears to be low. Only small limestone deposits which are difficult to access. Chuuk – Hard rock (volcanic) reserves but currently only two quarries, one of which may not be operational. Past sand mining but current status unknown. Pohnpei – Currently two operational hard rock / volcanic scoria quarries. Historically environmentally harmful coral dredging from reefs. Potentially very substantial sand deposits in some locations. Kosrae – Currently two operational gravel / sand quarries with volcanic origin. UN trade data indicate only very small aggregate imports over the past 3 years but with a very large infrastructure pipeline and limited resources in some states, there is likely only a low to medium level of aggregate self-sufficiency.
Fiji	**Very high** As one of the largest economies in the Pacific, Fiji has a very large infrastructure project pipeline, in the order of $2.7 billion. PRIF has identified projects budgeted at $682.5 million.	- Volcanic rock - Limestone - River gravel and sand - Coastal sand / gravel (no current extraction) - Lagoon sand / gravel (no current extraction)	**High** 2020–2022 imports: ~388.9 tons 2020–2022 exports: 45,005 tons Significant aggregate resources of all types (limestone, basalt/ volcanics river sand and gravel) plus numerous operational quarries and river extraction sites. Fiji is an important exporter to the region and has reasonable self-sufficiency. The main challenge is sourcing these aggregates responsibly, particularly from Fiji's rivers. In addition, recent discussions with the

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			MRD indicate that despite being an exporter, Fiji is currently facing challenges meeting domestic aggregates demand.
Kiribati	**High** Large infrastructure pipeline with approved projects from Kiribati's NIIP (2022–2032) valued at a $562.37.	- Lagoon sand / gravel - Dolomite / limestone (Banaba island only)	**Low** 2020–2022 imports: ~8,042 tons 2020–2022 exports: 0 Successful sand extraction operations (ESAT) in Tarawa but (with the exception of the unrealized Banaba dolomite resource) no other types of aggregate, which makes it highly reliant on imports of hard rock, gravel etc. from countries like Fiji.
Republic of Marshall Islands	**Low-medium** The Marshall Islands National Strategic Plan 2020–2030 does not provide detail on specific infrastructure projects however, PRIF has identified 4 projects for potential funding at a cost of $52.86 million.	- Lagoon sand / gravel	**Low** 2020–2022 imports: ~2,317 tons 2020–2022 exports: 0 tons Highly dependent on import of hard rock aggregate, including armor rock for coastal protection and other works. However, based on available information, infrastructure pipeline appears to be relatively modest, with the Majuro airport terminal ($32 million) likely to need the most aggregate resources for runways, etc. Also, potentially good sand deposits at the northern rim of Majuro lagoon could meet some of this demand for this type of aggregate.
Nauru	**Low** "Priority" projects from Nauru's Integrated Infrastructure Strategic Plan 2019–2030 estimated to cost around $68.79 million.	- Dolomite / limestone	**Medium to High** 2020–2022 imports: ~12.5 tons 2020–2022 exports: 0 tons Nauru has a substantial dolomite reserve that should theoretically be able to fulfill all or most coarse aggregate needs over the coming years (and, if managed properly could be a source of exports). Minor quantities of sand imports (~12.5 tons) over past 3 years indicate it may require continued imports of sand / gravel in coming years.
Niue	**Moderate** For the relatively small size of the country, there is a relatively substantial infrastructure plan valued at $173 million over 10 years (2023–2033).	- Limestone	**Low-medium** 2020–2022 imports: ~6.4 tons 2020–2022 exports: 0 tons Only two identified limestone quarries - small quantities of sand imports over past

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
			3 years indicate reasonable level of self-sufficiency. However, relatively large infrastructure pipeline may put pressure on existing quarries requiring increased imports of sand and other types of aggregate.
Palau	**Low to moderate** Top 20 prioritized projects in the National Infrastructure Investment Plan (2021–2030) are valued at $243 million and will require substantial quantities of aggregate for construction. PRIF has identified projects valued at $59.7 million.	- Limestone - Volcanic rock - Lagoon / coastal sand and gravel dredging	**Low to medium** 2020–2022 imports: ~114.3 tons 2020–2022 exports: 0 tons Five active quarries with volcanic and limestone rock and sand should be able to meet much of the aggregate demand, though past years have still required modest imports of sand, gravel etc.
PNG	**Very high** Very large infrastructure pipeline in the order of $1,826.4 million for potential PRIF projects alone. In addition, the "Connect PNG Plan 2020-2040" will require massive quantities of aggregate to build or rehabilitate 4,200 km of national roads and 16,200 km of provincial and district roads.	- Volcanic rock - Limestone - River gravel and sand	**TBC** 2020–2022 imports: ~ 1,450.4 tons 2020–2022 exports: 143 tons Over 23 quarries identified at time of writing plus potentially numerous other resources (and quarries) not identified. However, PNG's infrastructure pipeline, including road building is massive and will require extremely large quantities of aggregates for roads and other infrastructure. Also noteworthy is that PNG still imports aggregate (~1,450 tons between 2020–2022). Aggregate resources are potentially available but surveying and establishing a significant aggregates sector will require substantial resources and capacity building.
Samoa	**Medium-High (TBC)** A new national infrastructure plan has not been released following the 2011 5-to-10-year plan. The Apia Port upgrade project which has required significant volumes of aggregate is also scheduled for completion soon. However, a new Transport Infrastructure Plan has been developed and identifies several major projects which will require large volumes of aggregate.	- Hard rock (basalt) - Sand	**Medium** 2020–2022 imports: ~546 tons 2020–2022 exports: 0 tons Excellent basalt resources which appear to be largely sufficient to meet current demand, though ~546 tons of aggregate (mostly gravel/pebbles) imported in the last 3 years.
Solomon Islands	**High** The government's priority infrastructure pipeline of 2021 identified projects valued at $368	- Limestone - River gravel / sand - Hard rock (volcanic)	**Low-medium** 2020–2022 imports: 26 tons 2020–2022 exports: 0 tons

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	million. It is not yet known whether the projects identified will go ahead but PRIF has identified eight large projects with a total value of $264.5 million. As a result, it seems likely that aggregate demand will be substantial in the coming years.		Almost all of the building materials permits issued are for river sand and gravel operations along the Lungga, Ngalibiu and Poha rivers, near Honiara with significant environmental and aggregate quality challenges. Hard rock resources (predominantly diorite) are available but will require substantial resources and capacity building to develop. Nevertheless, at least according to UN Comtrade data, Solomon Islands only imported around 26 tons of aggregate during the 3-year period 2020–2022.
Tonga	**Medium** The National Infrastructure Investment Plan (NIIP) identifies ~$232.75 million in priority projects to be implemented between 2021 and 2030. $197.1 million in projects have been identified by PRIF.	- Limestone - Beach sand (not sustainable)	**Low-medium** 2020–2022 imports: 124.6 tons 2020–2022 exports: 0 tons Tonga has only limestone resources of varying quality to supply the infrastructure construction projects in the coming years. There will likely be a continued need to import better quality materials and sand to supply the infrastructure sector in the coming years, particularly sand, though only a modest 124 tons of aggregate was imported between 2020–2022. Nevertheless, the relatively large pipeline will likely increase aggregate demand beyond what Tonga can produce itself.
Tuvalu	**Medium** Compared to other countries in the region, Tuvalu has a modest infrastructure pipeline, with many of the projects identified under the 10-year Infrastructure Strategy and Investment Plan (2017–2026) likely to have already been completed, based on predicted timelines. PRIF has identified $70.6 million of future projects, with most requiring the importation of aggregates.	- Lagoon sand / gravel	**Low** 2020–2022 imports: 12,135.8 tons 2020–2022 exports: 0 tons Successful sand extraction operations for land reclamation (under TCAP) but there are no other types of aggregate locally available, which makes it highly reliant on imports of hard rock and gravel from countries like Fiji. Imports between 2020–2022 totaled more than 12,000 tons and, based on infrastructure development plans and other future coastal adaptation works, these levels of aggregate import will likely continue over the coming years.
Vanuatu	**Medium to High** Current infrastructure development plan ends this year with new plan yet to be released. However, proposed projects will likely be as much, if not more, than	- Limestone ('coronus' material) - Basalt (mainly outer islands) - River gravel (outer islands)	**Low-medium** 2020–2022 imports: 27.9 tons 2020–2022 exports: 0 tons

Country	Scale of aggregates needed for future infrastructure development (low, moderate, high, very high)	Existing aggregate sites and known resources	Preliminary assessment of current self-sufficiency (very low, low, medium, high)
	the Vanuatu Infrastructure Strategic Investment Plan 2015 – 2024, which identified projects valued at $406 million. Projects identified by Pacific Regional Infrastructure Facility are valued at $171 million.	- Beach sand (not sustainable)	Good limestone deposits on Efate but limited basalt with no operational quarry. Outer islands have sand, river gravel, limestone and small (but potentially bigger) quantities of basalt resources though Vanuatu is still reliant on imports, with very large imports in recent years, though not all captured by trade data.

TBC = to be calculated.

Source: Analysis by authors using country NIIPs, PRIF infrastructure pipeline data, and import-export data from UN Comtrade

The atoll countries of Kiribati, the RMI, and Tuvalu are, not surprisingly, most constrained by their geography and geology. But even countries which have established quarry operations such as Palau, Solomon Islands, Tonga and Vanuatu are currently reliant on imports from Fiji and other countries, particularly in sourcing the right kind and quality of aggregates, such as gravel, armor rock and even sand.

This highlights just how important Fiji is the supply of aggregates in the region. Over the past 5 years, with a few exceptions, it has been the only PIC to supply aggregates to other countries in the region, with Kiribati, Tuvalu, and the RMI being the biggest consumers of materials. Aggregate is also imported from numerous other countries outside the region, such as Australia, New Zealand, the PRC, and even as far away as Türkiye and Norway. Yet Fiji's role remains critical, supplying an estimated 55% of all aggregates in the 5-year period between 2018 and 2022. If what appear to be anomalous shipments from Norway in 2018 are excluded, this rises to 79%. In short, Fiji's role as a supplier of aggregates is critical and unless its resources are managed more sustainably, there is a risk that extraction will result in significant harm to river and coastal ecosystems, human health, and livelihoods.

For their part, infrastructure developers, whether they are the contractors who develop the infrastructure, or the donors who fund it, have faced challenges related to aggregate supply. These include lack of appropriate port facilities to load or unload supplies, high aggregate and transportation costs, inability to access the right kind and quality of aggregate at the right time and price, and limited skills and capacity within both industry and government to ensure efficient and sustainable supply of materials. In some countries, legal and policy frameworks capable of regulating the aggregates sector do not exist, are poorly developed or, most commonly, not enforced. The lack of enforcement is usually the result of a lack of resources and government capacity. To give one example, the Initial Environmental Examination for the ADB Outer Island Maritime Infrastructure Project in Tuvalu found that the Department of Environment had limited staff capacity to provide compliance monitoring especially in the country's outer islands.

The economic and social impacts of the aggregates sector are also poorly understood, including OHS systems and performance at the quarry level, employment contribution of the sector, its contribution to GDP, and royalties collected. In large part this is due to poor monitoring, reporting, and public disclosure of performance data.

The study also finds that there are several promising alternative sources of aggregate in the region which have not been utilized, or fully utilized, that have significant potential to meet at least some of the aggregate demand from infrastructure development. Nauru's dolomite resources stand out as a highly significant source of quality aggregate, which is suitable for many applications, from concrete to road surfacing. This may also be the case with the dolomite resources on Kiribati's Banaba Island. In the case of Banaba, surveys suggest that there may be as much as 2 million tons of limestone aggregate which would not only go much of the way to making Kiribati self-sufficient, but also enable it to become a dolomite exporter to other countries in the region.

Another potential source of aggregate is the Le Sland in New Caledonia. A stockpile of 25 million tons is currently not being used and a further 1 million tons is added each year, despite the best efforts of French company SLN to all but give it away. And finally, comprising half of the second-largest island in the world, PNG likely has enormous aggregate resources, though only a fraction of this appears to be used, with much remaining to be surveyed. Longer term, there is also the possibility of manufacturing ore sand in some of the region's existing and upcoming metallic mines, such as in Fiji and Solomon Islands.

The recommendations provided in the final section of this report, seek to address many of the above challenges, including strategies to benefit from potential alternative sources of supply.

7.2 Recommendations

The recommendations presented here should be viewed as preliminary and will be refined following input from key stakeholders. They are divided into seven categories as follows: 1) improving sustainable extraction practices through adoption of a set of Principles for Responsible Sourcing of Aggregates in the Pacific; 2) building on lessons learned to improve sustainable aggregate supply in resource poor atoll countries; 3) improving knowledge of aggregate resources in the region; 4) better management of information and data; 5) enhancing capacity to monitor and enforce compliance with regulation and good extraction practices; 6) addressing other challenges reported by infrastructure developers; and 7) utilizing alternative aggregate sources in the region.

1. Improving sustainable extraction practices through adoption of Principles for Responsible Sourcing of Aggregates in the Pacific

- **Refine and further develop the responsible sourcing principles:** the responsible sourcing principles developed in this study provide a basic framework for responsible aggregate sourcing practices. They differ from various donor safeguards in that they are adapted for the region and sector. However, they are only an initial step and will require refinement and, most importantly input and buy-in from regional stakeholders. We recommend the following actions are taken to achieve this:
    - **Conduct regional workshops** to obtain to ensure a) they address all key sustainability issues affecting the sector in the region; b) are realistic and can feasibly be adopted and implemented; and c) will be effective and lead to positive change. Experience suggests that in-person workshops are much more effective in ensuring attendance and active participation. One option is to hold three separate workshops grouping countries facing similar resource constraints and other issues. Participants in these workshops should include staff of key agencies regulating the sector in each country, representatives of infrastructure contractors and donors, and representatives of local or regional civil society groups to provide a chance for local communities to provide input.
    - **Finalize the principles and develop accompanying implementation guidance:** Following the workshops, the principles should be finalized and implementation guidance developed to accompany them. This guidance should also be sent out to key stakeholders for peer review.
- **Support transitions from river gravel and sand extraction to hard rock quarrying in countries such as Fiji and Solomon Islands**: This was a recommendation of the 2018 Baseline Assessment of Development Minerals, which stated that in Fiji initiatives will be needed to improve access to finance, review royalty and licensing application fees (which currently favor gravel extraction),

undertake business process mapping on licensing procedures, create templates for partnerships with iTaukei landowners, and promote domestic investment through a collaboration between the Mineral Resources Department and Investment Fiji. Similar measures will likely be needed in Solomon Islands to support a transition to quarrying.

2. Build on lessons learned to improve sustainable aggregate supply in resource poor atoll countries

- **Evaluate the potential benefits and feasibility of establishing projects like ESAT and TCAP in other PICs, such as the RMI, where extraction of lagoon or coastal sand and gravel is having negative environmental impacts**: Both ESAT and TCAP are delivering positive outcomes in terms of providing a supply of sustainably sourced material for land reclamation and construction purposes. For instance, in the RMI, the need for coastal protection around Ebeye is particularly critical because of its small size, high population density and exposure of critical infrastructure to wave action with little option of retreating due to constrained land availability. Surveys conducted decades ago indicate there may be vast lagoon resources that can be exploited. Current surveys being conducted by SPC through World Bank-funded PREP II project identifying aggregate resources for construction are an initial step to doing this. Other PICs with potential lagoon resources within atoll contexts should also be explored, such as the FSM. It is critical that lessons learned from these projects are incorporated into future programs. SPC's Geoscience, Energy and Maritime division is well placed to provide this support.

  It should be cautioned, however, that lagoon sand and gravel resources are not a replacement for armor rock / riprap and other hard rock materials necessary for coastal protection, which many atoll countries and regions simply do not have. One alternative solution is to increase the supply of prefabricated concrete products, such as Seabee unit pods from Fiji, where manufacturing of these products is well established.
- **Provide alternative livelihood options and skills development to ensure bans on illegal beach sand mining and lagoon extraction do not harm local people:** Efforts to enforce bans on beach sand mining or illegal lagoon dredging must be accompanied by measures to provide employment and economic opportunities for those whose livelihoods may be displaced. Without such support mechanisms, efforts to end illegal mining will likely be ineffective and, at worst, harm those who depend on extraction for their livelihoods. As a first step, this could entail provision of job training and opportunities to work on new dredging projects for sand miners.

3. Improving aggregate resource knowledge in the region

- **Provide support for surveys in countries where there is limited knowledge of aggregate resources:** The study found that information about the region's aggregate resources and potential is patchy and limited to relatively few areas, despite the various resource assessments conducted in the past by organizations such as SOPAC (now SPC). If the region is to improve the availability of aggregate resources for infrastructure development, contractors, donors, and governments need more comprehensive knowledge of the local materials available. For instance, knowledge of PNG's aggregate resource potential is largely unknown, unlike knowledge of the country's high-value mineral potential. This is, in part, due to the low value traditionally placed on aggregates and other "development minerals" by governments and even donors, even though these minerals are essential for infrastructure and local economic development.

4. Better management of information and data

- **Countries should establish centralized databases of quarries and other extraction sites, including developing a comprehensive geographic information system (GIS) database:** Even where data on aggregate extraction operations exists, it may not be collated in one place within government or available to infrastructure developers or other users. For instance, Fiji, which has the most developed quarry and river gravel extraction sectors in the region, does not have a centralized database. Information is held by three separate institutions, the MRD, DoL, and TLTB, each of which is governed by different regulations. Vanuatu and PNG face similar problems. In the former, some data is held by the PWD, while other data is held by the Department of Geology and Mines. It is a similar situation in PNG, with different data is held by the MRA, Department of Works and Highways and, perhaps, other agencies. Centralized access to this information is particularly important in PNG, which will have massive aggregate demands to build and repair thousands of kilometers of roads alone in the coming years.

  - **At a minimum, governments should bring together all existing data into one place** so that its own agencies and other parties can easily assess resource information. The database should have information on location and type of resource, details of current licenses (including the license holder), information on past breaches of license conditions, maximum allowable extraction volumes, and actual volumes extracted per year.
  - **Ideally, a GIS database of these extractive operations should be created in alignment with good practice**. Most governments in the region will likely require financial assistance and support with training and skills development to achieve this. It should be noted that Fiji has a GIS but, as with the actual compilation of extraction data, it does not appear to cover aggregate operations regulated by the TLTB.

- **Relevant government agencies should compile and publicly report on the economic and social impacts of aggregate extraction:** The study found that reporting on such things as OHS performance, employment, GDP contribution and royalties generated by the sector is absent in most countries and, even where it is reported, is not up to date. For instance, seven of the countries in the region do not report any data on employment in the quarry and mining sector (which are usually grouped together in official statistics). Only four countries report on the quarry and mining sector's contribution to GDP, though one of these, Solomon Islands has not reported any data since 2016.

  Relevant government agencies must have visibility of this performance since it is essential to policy development and improving performance, whether this is safety performance or increasing economic returns. It is also desirable that environmental performance data is compiled and, ideally, publicly reported.

5. Knowledge transfer and capacity building

- **Conduct training in good quarry management practice and related skills:** Skill areas could include:
  - Proper benching practice to ensure safe and efficient extraction of rock
  - Explosives handling and use
  - Natural disaster planning and risk management at quarry sites
  - Good practice site maintenance, including environmental management and rehabilitation.
  - Good practice OHS
- The knowledge transfer could take the form of workshops, short courses, or other training programs delivered in-country or at universities such as Fiji National University and the University of the South Pacific. The World Bank is reportedly seeking a contractor to deliver OHS training for quarries in Samoa. UNDP has previously conducted OHS training for 27 quarry workers and quarry operators in Fiji under the ACP-EU Development Minerals Programme. A similar program could be adopted in Samoa and elsewhere.
- **Provide relevant government agencies with the resources and skills to monitor and enforce compliance with environmental regulations:** Poor or non-existent environmental monitoring and enforcement is a major problem in PICs, even in countries such as Fiji. It is essential that government agencies with responsibility for monitoring are provided with the financial and human resources to undertake this monitoring on a regular basis. EIA training by organizations

such as SPREP's Environmental Monitoring and Guidance Division, which produced successful outcomes in Niue, could be delivered in other countries in the region, prioritizing those facing heightened challenges in maintaining environmental compliance.

- **Each country should develop and make publicly available a Quarry Management Guide.** Like the Quarry Management Guide produced by Vanuatu's PWD, the guide would outline the key requirements for establishing, operating and closing a quarry so operators and regulators know what is expected and can follow or enforce permit conditions.

6. Addressing other challenges reported by infrastructure developers

A range of other challenges to sourcing aggregate of the right quality for infrastructure development were reported by developers and other key stakeholders. These, along with recommended actions to address these challenges are discussed below.

- **Provide necessary facilities and expertise to test aggregates for quality,** especially in countries and areas undergoing large infrastructure investments. Support may be needed to establish, or maintain accredited laboratories, calibrate equipment, and recruit or train staff with requisite skills.
- **Ensure good practice community engagement to avoid landowner disputes over land access, royalties and other issues in potential quarry operations:** Experience in the large-scale mining sector demonstrates that positive early engagement with landowners, including indigenous peoples, is essential when seeking to develop extractive operations. There is a range of good practice guidance to support companies with this, such as the International Council on Mining and Metals' (ICMM) Indigenous Peoples and Mining Good Practice Guide (2nd Edition) and many others.
- **Requiring contractors to prepare a detailed aggregate / construction materials sourcing plan in their bids for infrastructure projects**. The plan should include detailed supply chain mapping that identifies each component of the supply chain (e.g., quarry site, transportation, distribution, etc.) and potential vulnerabilities. The plan should seek to assess the level of risk at each part of the supply chain and develop appropriate risk mitigation measures.[575]
- **Address transportation costs and other transport related challenges**. Reducing transportation costs can be achieved through greater use of local materials. For example, as mentioned in number 2 above, the success of ESAT and TCAP programs suggest that even aggregate-scarce countries like Kiribati and the Tuvalu can provide for at least some of their own aggregate needs. There is potential to establish such programs in the RMI, the FSM, and elsewhere. Previous work by PRIF has also revealed that there is room for the greater use of local coralline materials, such as coral rock in the construction of roads, particularly when combined with good pavement design and construction practices.[576] More strategic supply chain planning (see point above) can also help in identifying sources of local materials before projects have been designed. Donors may also wish to provide grants to importing countries to build boat ramps capable of handling landing barges ahead of major infrastructure developments.

[575] World Bank (2023). *Procurement Guidance for Supply Chain Management: An Introduction and Practical Toolset for Procurement Practitioners*. https://thedocs.worldbank.org/en/doc/1c3b517f003b53a2e2e170e93124be84-0290032023/original/World-Bank-Supply-Chain-Management-Guidance.pdf. Accessed 05/04/2023.

[576] Pacific Regional Infrastructure Facility (2016). *Road Pavement Design for the Pacific Region: Desktop Research of the Use of Local Materials*. https://www.theprif.org/document/regional/transport/road-pavement-design-pacific-region#:~:text=The%20study%20investigated%20options%20to,of%20road%20construction%20and%20maintenance. Accessed 15/04/2024.

7. Utilizing alternative aggregate sources in the region

- **In Nauru, the government with the support of international donors should provide financial and technical support to the nascent dolomite quarry industry.** According to some studies, Nauru has an estimated 30.5 million m^3 that could not only make the country self-sufficient in quality aggregate but could also be a significant source of aggregates for the region. However, this export market is constrained by various barriers. Overcoming these will require:
    - **Undertaking a study to fully assess the market potential for dolomite in the region** and ensure investment in expanding the export industry in Nauru will be economically viable. This could entail in depth research with government agencies, contractors, and donors to quantify expected aggregate resource demand. It could also entail deeper analysis of the quantities of aggregate required by infrastructure projects in the project pipeline, for example by examining Bills of Quantities for past infrastructure projects and using these to predict specific quantities and type of aggregate needed.
    - **Addressing landowner issues.** Current quarry operations are on government land or NRC landholdings; however, other quarry sites lie on customary private land.
    - **Provide affordable finance for NRC to purchase and maintain a suitably sized barge to overcome shipping constraints.** At present, delivery to countries such as Kiribati and Tuvalu is a major barrier due to the lack of regular shipping and unsuitable port facilities, which require onloading and offloading cargo offshore. Additional finance may be needed to purchase plant and equipment, to support the expansion of extraction in the coming years.
    - **Put in place a human capital management strategy** to ensure the industry has sufficient expertise to operate efficiently and safely. This strategy could be supported through the recommendations provided above on knowledge transfer and capacity building, particularly in areas such as explosives handling given Nauru has a shortage of trained blasters.
    - **Ensure there are sufficient roads and tracks to enable operators to access new dolomite deposits.** Currently, access remains a challenge and must be improved if the quarry sector is to be expanded.
    - **Ensure dolomite extraction contributes to successful rehabilitation of phosphate mining areas.** This will require establishing sustainability parameters for extraction so that removal of dolomite complements rehabilitation efforts, rather than create new problems. This will require collaboration between mined land rehabilitation experts, such as those at The University of Queensland's Centre for Mined Land Rehabilitation, NRC / RONPHOS, and government.
- **Take initial steps to explore the potential of creating a limestone / dolomite export industry in Banaba, Kiribati:** These steps should include:
    - **Consult with Banaba citizens living in both Banaba and Rabi Island,** to determine people's desire to develop a domestic quarry industry. This is of particular importance and sensitivity given the history of population displacement caused by the phosphate industry, and current proposals by one company, Centrex, to recommence secondary phosphate mining in conjunction with quarrying dolomite. Nevertheless, consultations with officials in Kiribati indicate there is interest with at least some in government to explore dolomite mining, especially if the ventures are led by local companies and landowners.
    - **Draw on the study, if undertaken, for Nauru to fully assess the market potential for dolomite in the region** and ensure investment in developing an export industry in Banaba will be economically viable.

    - **Invest in improving port facilities in Banaba** so that there are suitable landing and loading facilities for vessels to ship aggregate. Facilities are currently not fit for purpose.
    - **Provide financial support for the purchase of plant and heavy equipment** necessary to develop a quarry sector on the island. Necessary equipment includes large excavators and front-end loaders to transport materials. In the meantime, initial actions to get the quarry sector up and running could include the purchase of small excavators and portable rock drilling equipment which would enable quarries to build rock stockpiles for later export.
    - **Undertake a work program to clear access roads:** currently, growth of thick vegetation in areas with potential dolomite deposits is impeding resource assessment and access and will need to be cleared as part of preliminary assessments.
- **Commence engagement with metal miners in Fiji and Solomon Islands to explore interest in producing ore sand:** There is currently one operational gold mine in Fiji, and two in Solomon Islands that could produce ore sand from mineral ores by adding additional processing circuits. Companies such as Brazilian mining company, Vale, are already producing and selling ore sand as an aggregate in Brazil. A structured program of engagement with the owners of mines in the region could be undertaken to determine interest. Recent conversations at the Science, Technology, and Resources Conference in Fiji in November 2023 indicate that at least one of these companies is interested in investigating production of ore sand from mineral ore at its newly producing mine in Fiji. A second large international mining company with an advanced exploration in Fiji is already commencing the necessary studies to produce ore sands at other locations in other countries.
- **Undertake a market study to determine regional interest in using New Caledonia's ferro-nickel slag, as an aggregate in the region:** Initial testing of Le Sland indicates it can be used as an aggregate with a wide range of applications, such as concrete and sandbags to prevent coastal erosion. Le Sland has so far been exported to countries such as Tonga and Vanuatu on a limited scale; however, the company appears concerned that uptake of this aggregate is not reaching its potential.
- **It is recommended that the company fund a market study to assess interest in this product**. Key stakeholders targeted in the study should include key infrastructure contractors in the region and relevant government agencies in each country, such as infrastructure departments, environment departments, and standards agencies. PRIF should also be part of the study given its recement support for the development of building codes in the region.
- **Maximize the use of local materials through appropriate engineering practice:** In many cases, adopting new techniques for drying coralline material can produce aggregate that is of higher quality, fit for purpose, and will reduce the need for some aggregate imports. The effective use of local coralline material by the US army to build causeways, roads, and runways during the Second World War is a good illustration of this, as is the example of seawalls built in the RMI during the Japanese occupation which are still standing today. Pilot studies and projects could be established in carefully selected places to explore alternative, nature-based holistic engineering practices.

Appendix A – Summary of the Requirements for Engaging with Indigenous Peoples in the ADB Safeguard Policy

Requirement	Description
GENERAL REQUIREMENTS	
Consultation and Participation	Consultations must be carried out with impacted Indigenous communities to ensure informed participation in the design, implementation and monitoring adverse impacts, and tailoring project benefits that accrue to them in a culturally appropriate manner.
Social Impact Assessment (SIA)	Carry out full SIA, and if adverse impacts are identified, an IPP should be carried out to address those impacts and recommend mitigation measures.
Indigenous Peoples Plan (IPP)	An IPP sets out the measures to ensure that affected Indigenous Peoples receive appropriate social and economic benefits; and that when potential adverse impacts on Indigenous Peoples are identified, these will be mitigated or avoided to the maximum extent possible.
Information Disclosure	The SIA and IPP will be publicly available through their website.
Grievance Redress Mechanism	A mechanism should be established to receive complaints and facilitate resolution of Indigenous Peoples.
Monitoring and Reporting	The implementation of the IPP should be monitored and reported to track performance.
Unanticipated Impacts	If unanticipated impacts occur, such as an expansion of operations, a social impact assessment should be undertaken and IPP updated.
SPECIAL REQUIREMENTS	
1. Ancestral Domains and Lands and Related Natural Resources	When preparing the SIA and IPP, the project developer should consider the customary land tenure systems and get the consent of customary landowners on the conversion of the customary use rights to communal/individual land rights.

2.	Consent of Affected Indigenous Peoples Communities	- Consultation process must include: process and outcomes of consultations with Indigenous Peoples, including (a) the findings of the SIA; (b) the additional measures, including project design modification, that may be required to address adverse impacts and to provide them with culturally appropriate project benefits; (c) the recommendations for meaningful consultation with and participation by Indigenous Peoples communities during project implementation, monitoring, and evaluation; and (d) the content of any formal agreements reached with Indigenous Peoples communities and/or Indigenous Peoples' organizations. - Physical Displacement: Explore to the maximum extent possible alternative project designs to avoid physical displacement of Indigenous Peoples that will result in adverse impacts on their identity, culture, and customary livelihoods. - Commercial Development of Cultural Resources: support them in their development planning and poverty reduction strategies by providing employment, addressing gender issues, strengthening local legislation and strengthening the capacity of governments and Indigenous communities or boards.
3.	Indigenous Peoples and Development	- Strengthen legal recognition of customary land tenure. - Ensure Indigenous participation in development planning and poverty reduction strategies. - Support their development priorities through government programs developed in cooperation with Indigenous People. - Address the special issues facing women and other vulnerable groups in Indigenous communities. - Prepare participatory profiles of Indigenous Peoples to document their culture, demographic structure, gender and intergenerational issues, social organization, institutions, production systems, religious beliefs, and resource use patterns. - Strengthen capacity of Indigenous Peoples to participate, prepare, implement, monitor and evaluate development programs. - Strengthen capacity of government agencies responsible for Indigenous Peoples development. - Preserve and respect Indigenous knowledge and intellectual property rights. - Facilitate partnerships among the government, Indigenous organizations, civil society

	organizations, and the private sector to promote Indigenous Peoples' development programs.

Appendix B – List of Stakeholder Consultations

Stakeholder category	Organization	Number of people consulted
Infrastructure developers / donors	ADB	6
	DFAT (AIFFP)	3
	DFAT (APCP)	1
	DFAT (Climate Sustainability Division)	1
	FRA	1
	JICA	2
	PRIF	3
	Roads 4 Development (Vanuatu)	3
	R4D / Partisipa (Timor)	3
	SIIP (Solomon Islands)	2
	TSSP (PNG)	1
	World Bank	7
	Former donor technical advisors	3
	PREP	1
Subtotal		**37**
Other international organization	Pacific Community	3
	NIWA	1
	Nature Conservancy	1
	UNDP	2
Subtotal		**7**
Infrastructure contractors and consultants	Concrete Solutions	2
	Douglas Concrete	1
	Downer	1
	Hall Contracting	1
	Highway Stabilizers	2
	Jacobs	2
	Reeves Envico	3
	Tonkin and Taylor	3
	Monier Ltd (PNG)	2
	JoeMar Construction (RMI)	1
	MJCC (RMI)	1
Sub-total		**19**
Government	The Cook Islands	1
	Fiji	3
	Vanuatu	7
	Samoa	9
	Solomon Islands	18
	The Marshall Islands	13
	Tuvalu	1
	Kiribati	1
Subtotal		**53**
Quarry / extractive operators	Fiji	5
	Vanuatu	2
	Samoa	3
	Solomon Islands	10
	Marshall Islands	3
	Papua New Guinea (as above for Monier Ltd)	-
Subtotal		**23**
Other industry	New Caledonia (SLN)	1
	Fiji (Cruz Holdings, EIF International)	3

Stakeholder category	Organization	Number of people consulted
	Mayur Resources (PNG)	2
Subtotal		**6**
Community representatives	Solomon Islands	6
Subtotal		**6**
Total		**151**

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