Deep Sea Minerals and the Green Economy

Edited by Elaine Baker and Yannick Beaudoin
Steering Committee
Akuila Tawake (Chair) Secretariat of the Pacific Community/SOPAC Division
Elaine Baker GRID-Arendal at the University of Sydney
Yannick Beaudoin GRID-Arendal
Malcolm Clark National Institute of Water & Atmospheric Research Ltd (NIWA)
Daniel Dumas The Commonwealth Secretariat
Chuck Fisher Penn State University
James R. Hein United States Geological Survey (USGS)
Robert Heydon Offshore Council
Harry Kore Government of Papua New Guinea
Hannah Lily Secretariat of the Pacific Community/SOPAC Division
Michael Lodge International Seabed Authority
Linwood Pendleton Duke University, NOAA
Sven Petersen GEOMAR
Charles Roche Mineral Policy Institute
Julian Roberts The Commonwealth Secretariat
Samantha Smith Nautilus Minerals Inc.
Anne Solgaard GRID-Arendal
Jan Steffen International Union for Conservation of Nature
Arthur Webb Secretariat of the Pacific Community/SOPAC Division

Editors
Elaine Baker and Yannick Beaudoin

Authors
Elaine Baker GRID-Arendal at the University of Sydney
Yannick Beaudoin GRID-Arendal
Sara Bice University of Melbourne
Lee Burns University of Sydney
Daniel Dumas The Commonwealth Secretariat
John Feenan IHC Mining
Nick Hanley University of Stirling
Porter Hoagland Woods Hole Oceanographic Institution
Paula Holland Secretariat of the Pacific Community/SOPAC Division
Niels Jobstvogt University of Aberdeen
Hannah Lily Secretariat of the Pacific Community/SOPAC Division
Michael Lodge The International Seabed Authority
Julian Roberts The Commonwealth Secretariat
Linwood Pendleton Duke University
Anne Solgaard GRID-Arendal
Philip Symonds University of Wollongong
Charles Roche Mineral Policy Institute
Akuila Tawake Secretariat of the Pacific Community/SOPAC Division

Reviewers
Joshua Brien The Commonwealth Secretariat
Bill Edeson Forum Fisheries Agency
John Feenan IHC Mining
Marea Hatzilos The World Bank

Geoffroy Lemaître The National Institute of Water and Atmospheric Research
Paul Lynch Government of the Cook Islands
Gavin Mudd Monash University
Christian Neumann GRID-Arendal
Antonio Pedro United Nations Economic Commission for Africa
Rosmary Rayfuse University of New South Wales
Jonus Rupp Conservation International
Richard Schodde MinEx Consulting
Annie Kwan Sing-Siose Secretariat of the Pacific Community/SOPAC Division
Nikki Teo University of Sydney
Darryl Thorburn Government of the Cook Islands
Martin Tsamenyi University of Wollongong
Robin Warner University of Wollongong

Cartography
Kristina Thygesen GRID-Arendal
Riccardo Pravettoni GRID-Arendal

Front Cover
Alex Mathers

Technical Editors
Claire Eamer
Patrick Daley

Production
GRID-Arendal

Acknowledgments
Special thanks to Akuila Tawake and Hannah Lily from the Secretariat of the Pacific Community/SOPAC Division, Peter Harris from Geoscience Australia, and Allison Bredbenner from GRID-Arendal for final reviews of chapters.

Citation


©Copyright Secretariat of the Pacific Community (SPC) 2013
All rights for commercial/for profit reproduction or translation, in any form, reserved. SPC authorises the partial reproduction or translation of this material for scientific, educational or research purposes, provided that SPC and the source document are properly acknowledged. Permission to reproduce the document and/or translate in whole, in any form, whether for commercial/for profit or non-profit purposes, must be requested in writing. Original SPC artwork may not be altered or separately published without permission.
4.0 Sustainable Economic Development and Deep Sea Mining

Linwood Pendleton¹, Anne Solgaard², Porter Hoagland³, and Paula Holland⁴
with additional contributions by Nick Hanley⁵ and Nils Jobstvogt⁶

¹ Duke University
² GRID-Arendal
³ Woods Hole Oceanographic Institution
⁴ Secretariat of the Pacific Community/SOPAC Division
⁵ University of Stirling
⁶ University of Aberdeen
Ensuring that deep sea mining will have a positive impact on Pacific Island communities requires supporting not only the economic capital upon which sustainable and resilient economies are built, but also the social and environmental capital. In this chapter, we will explore the potential benefits and costs of deep sea mining to the economic and environmental capital of coastal and small island developing states in the region. We also look at traditional and emerging ways to determine the economic, environmental, and social costs and benefits of mining.
4.1 Background: the oceanscape of the Pacific region

Almost all of the currently estimated 10 million South Pacific islanders (expected to reach 15 million by 2035 (SPC 2013)), live within 50 kilometres of the coast. The ocean territory, which far exceeds the Pacific islands’ land mass, has shaped the lifestyles and culture of the people. The ocean provides fish, shellfish, and sea plants that support both local communities and commercial fisheries. Coastal coral reefs and mangroves mitigate the impacts of storm surge and protect beaches. Coastal habitats provide firewood, fibres, and other resources. Ocean views are known to improve people’s well-being (Millennium Ecosystem Assessment 2005). Many coastal communities benefit from tourism, which generally relies on clean beaches, safe water, and abundant marine wildlife. Tourism generates jobs, income, and foreign exchange. Ocean recreation provides both market and non-market benefits to coastal residents. Ocean ecosystem processes provide ecological services and are an integral component of other global processes, such as the water cycle, nutrient cycling (including carbon storage), primary production of oxygen, and the regulation of climate.

The deep sea may now offer new opportunities for industrial development, including the extraction of minerals from the deep sea floor. Many existing industrial marine activities occur in the near-shore environment, whereas deep sea mining activity is anticipated to be far removed from the coastal and shallow-water ecosystems that are so important to many Pacific communities. The lack of direct human uses of ecosystems and their services in the deep sea, combined with new technological advances, means that deep sea mining could potentially have lower environmental and social impacts than land-based mineral extraction (see Chapter 3 in this volume). Nevertheless, impacts could result, both onshore and offshore. The lack of information about the ecosystems at depth and about the technology that will be employed in commercial extraction activities offshore means that there remains scope for unforeseen and direct impacts. Additionally, the deep sea environment presents difficult working conditions and unique technical issues that may make environmental monitoring and/or revenue collection difficult and costly.

To ensure that any development of deep sea mining improves the overall well-being of society, it is essential to understand each of the potential costs and benefits and their cumulative effects. Wealth creation from the sale of non-renewable resources needs to be weighed against any associated reduction in the economic value of other goods and services. By understanding this balance, policy makers can implement measures to ensure that the environmental and social costs of deep sea mining are managed and outweighed by the social benefits and economic returns from mining — and that these returns are invested and distributed equitably.

World oceans, a cornucopia of goods and services

Figure 4.1 Marine ecosystem services

Source: GRID-Arendal
A green economic approach to managing deep sea mining

Pacific Island developing states could potentially benefit from seabed mining if these activities contribute to Pacific economies in a way that is both financially productive and also green. A green economy is one in which market forces and opportunities are coupled with environmentally sound technologies to maintain or improve the economic, social, and environmental resource base on which coastal communities depend. (See UNEP’s report Green Economy in a Blue World for additional information, UNEP et al (2012)). In a greener economy, industry and business can contribute to creating new sources of income and jobs, while reducing the use of resources and the generation of waste (Figure 4.2). A green economy can also contribute to broader societal goals, such as sustainable development, social equity, and poverty reduction. A green economy can be viewed as an economic system that is compatible with the natural environment and ecosystems, environmentally friendly, and socially just (Sheng 2010).

Historically, Pacific communities have invested in their own welfare by converting their natural resources (fish, forests, mangroves, sand, etc.) into something of economic value. The conversion of natural capital into economic capital has been environmentally sustainable in many Pacific Island states, especially when the scale has been small and rules, whether formal or not, have been in place to limit impacts on living environmental resources. These rules are often based on an understanding of natural systems acquired over generations.

As an example, in the Pacific, taboos on fishing have commonly been used to manage where and when fishermen could catch fish in such a manner that fish stocks are maintained and continue to provide for the community. Managing these renewable resources effectively meant giving something back: in this instance, the time and space necessary to replenish ecosystem services.

This approach to using renewable resources ensured that the wealth from fisheries was ongoing, or sustainable. Sustaining the wealth generated from non-living resources, however, requires a different approach since non-living resources, such as deep sea minerals, cannot be replenished. To account for the contribution of natural capital to economic growth, deep sea mining profits need to be invested in social and environmental capital, as well as in other forms of economic capital. To support social capital, investments could create infrastructure and amenities that support the community, such as schools, hospitals, and other community facilities. Similar investments could be made in environmental protection or restoration.
“A green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.” (UNEP 2011)

A green economy is more holistic than a traditional economy focused primarily on economic growth. Instead, it recognizes three kinds of capital:

- Economic capital refers to standard forms of industrial capital, including infrastructure such as roads, communications, plants, and equipment.
- Social capital includes knowledge, skills, and experience comprising the ability of human beings to contribute to the production of economic value, as well as the broader social fabric in which it is embedded. This includes contributing to the cultural underpinnings of social institutions that, in turn, contribute to peace and sustainability.
- Natural capital includes the ability of the environment to support and produce goods and services that people value.

A green economy endeavours to maximize returns on social and natural capital, as well as economic capital (Figure 4.3). In a green economy, no single form of capital grows disproportionately at the expense of the others (Figure 4.4). All three forms of capital can be depleted, but, if equitably maintained, they can result in more resilient economies that produce sustainable value for the benefit of people.

Figure 4.3 The three capitals of a green economy.

Figure 4.4 Balancing the three capitals.
thereby improving the value of local natural capital. In this respect, communities can obtain a net beneficial return from the extraction of sea-floor minerals.

More generally, insufficient investment in social capital means that poverty could persist in the Pacific, despite any wealth that might be generated by mining. As an example, extensive mining development has been undertaken in Papua New Guinea in recent decades. Despite this, Papua New Guinea’s GDP per capita (recorded as $US2187 in 2012, ranking 179th of 229 countries worldwide; World Bank 2013) and human development index (recorded by UNDP in 2013 as 0.466, ranking 156th out of 187 countries worldwide; UNDP 2013) are still low, and poverty remains in the communities close to the mines. This appears to be due to inadequate institutional capacity, ineffective management, and inequitable capture and reinvestment of resource rents. Lal and Holland (2010) give examples of corruption, in which the wealth generated from the use of community-owned resources in Papua New Guinea has been managed in a way that has not benefited local communities.

Deep sea mining could contribute to a greener economy if:
- the economic benefits of deep sea mining exceed their economic costs;
- the environmental component of the costs of deep sea mining is adequately understood by all and is incorporated into the decision making of deep sea mining companies (including management of consequences, as appropriate); and
- a sufficient share of the wealth generated by mining (for example, through taxes or royalties) is invested in social and environmental capital in order to ensure the sustainability of wealth creation from finite resources.

### Limits to reinvestment of economic capital in natural capital: phosphate mining

The island of Kiribati provides an example of the value of investing the economic capital gained from a non-renewable resource in social capital. In the past, international companies carried out extensive phosphate mining on the island of Banaba. As early as 1956, it was realized that the phosphate resources were limited and a trust fund – the Revenue Equalization Reserve Fund (RERF) – was established to manage the earnings from phosphate mining. Since then, interest from Kiribati’s phosphate royalties has been available to the government and continues to be a critical source of budgetary income. In 2009, the fund was valued at around US$570 million (IMF 2011).

Nevertheless, reinvestment in social and natural capital can only go so far towards ensuring basic levels of environmental quality. For instance, phosphate mining can still lead to irreversible environmental damage if appropriate environmental limits are not set. Phosphate mining has dramatically reduced the agricultural and fishing potential of more than one Pacific Island state.
4.3 Assessing the economic impacts of deep sea mining

Like any type of resource use, extracting deep sea minerals and getting them to market can contribute to local environmental change, which could directly or indirectly compete with or displace other types of economic activity.

4.3.1 The potential market benefits and costs of deep sea mining

Private companies are beginning to consider commercial deep sea mining because the minerals found on the sea floor have substantial value on the world market. The net market benefit of these resources (that is, profit) depends not only upon the market price of minerals and metals, but also on the financial costs of exploration, permitting, management, extraction, and processing. The primary economic interest that Pacific Island states have in allowing or participating in deep sea mining is securing sales revenue by way of royalties on mineral production, taxation on profits, or access fees from foreign companies that require sovereign permission to access sea-floor resources. Such revenue, if managed well, could inject new wealth into national economies and have ripple effects throughout the national economy.

In Papua New Guinea, for example, over the period 1996 to 2000, the government raised revenue from mining through royalties, a mining levy on assessable mining income (in effect, an additional royalty), corporate income taxes and dividend-withholding taxes, an additional profits tax, and restrictions on deductions for off-site exploration expenditures (Otto et al 2006). In addition, the state reserved the right to assume up to a 30-per-cent equity share in all projects at the time a mining lease was issued, at a price based on the project’s exploration costs, not its full market value (Otto et al 2006).

Although these charges were subsequently reduced and streamlined, the magnitude of the potential wealth from mining in Papua New Guinea remains high, with mining consistently contributing between 10 and 20 per cent of national income over the years (Figure 4.5). Part of this wealth is also intended to reach communities, with the Papua New Guinea Mining Act requiring that owners of private land being mined receive a share of the total royalty (Otto et al 2006).

In practice, the degree to which these net market benefits will be enjoyed nationally or locally will depend on a host of factors. At a minimum, Pacific Island states could capture a share of the economic return from mining by charging fees, taxes, and royalties, which provide public sector revenues that could be reinvested locally.

Deep sea mining is anticipated to be expensive. It is capital-intensive, requiring large expenditures on vessels and equipment, processing, and transportation (although, in contrast to land mining, much of the machinery is designed to be moved from site to site). Some of the expenses associated with deep sea mining operations might be spent in the host country, which could create macro-economic ripples leading to new jobs and revenues in the host country.

Deep sea mining could also provide direct employment opportunities for a host country, indeed, this can be made a condition of relevant mining law and agreement. But such employment will depend upon the degree to which the administration, transport, and technical operations related to mining can be based locally. Potential sources of direct employment include shipping, aviation, warehousing, maintenance, construction, regulation, and monitoring (including laboratory services). In countries with well-developed labour forces – especially those where terrestrial mining already exists – highly skilled or technically specialized positions could be created for locals. In other Pacific Island states with less developed labour pools, migrant workers might (at least initially) fill highly skilled positions that could provide a basis for capacity building and technology transfer opportunities, benefitting the social capital of coastal and small island developing states.

Indirect employment – in hospitality, lodging, and provisioning industries, for example – could be generated if mining operations buy goods and services locally. Mining operations might also require the development of new local infrastructure (such as roads, ports, and power plants) that could serve to support or spur needed infrastructure development in host countries – although there has, to date, been little indication from industry actors in the region that onshore services would be sought from Pacific Islands. If as seems likely, operations in the Pacific take place wholly offshore, with the seabed mineral ore being transported by boat out of the region’s ocean and directly to countries (perhaps in Asia) with established processing industries, then the potential benefits to be derived from employment or infrastructure development should not be overstated.
4.3.2 The potential non-market benefits of deep sea mining

Exploration and exploitation of the sea floor will contribute to advances in technology and scientific understanding of these areas. Already, exploration of the sea floor at potential mining sites (the Solwara 1 site within Papua New Guinea’s national jurisdiction and the Clarion-Clipperton Fracture Zone of the Area) has led to the discovery of previously unknown species and new information on biological processes (Van Dover et al. 2012). It is difficult to attribute an economic value to these scientific discoveries (although some commentators consider that genetic resources might be the real treasure to be found at depth in the ocean), but it is clear that the costs of conducting research in the absence of commercial exploration, driven by potential mining profits, would likely be prohibitively high.

The potential economic benefits of technological advances are also difficult to quantify, but fall into two categories:

- advances that will improve the feasibility and profitability of future deep sea mining; and
- advances that will benefit other industries (such as deep sea tourism, cable laying, etc.).

In all cases, these benefits are unlikely to be enjoyed directly by the mining company, or even the Pacific Island states, but will have substantial economic benefits outside the region.

As noted, some habitats, organisms, and ecosystems that could be affected by deep sea mining might contribute to people’s economic well-being. Examples include food sources for commercially relevant fish, opportunities for scientific research, or potentially valuable genetic resources for biotechnology or medical applications. Future tourism to deep sea areas via submarine or through images is also a possibility. Commercial fishing, scientific research, and tourism all have direct value, known as use value, which can be estimated by market and non-market methods. If deep sea mining has detrimental impacts on these ecosystem services, the loss of value associated with these changes should be understood and considered by policy makers.

Deep sea mining is presented by some mining companies as a more environmentally sound alternative to terrestrial mining for similar minerals (see Chapter 3). Whether or not deep sea mining will ever displace terrestrial mining depends on a host of factors, including market forces, regulations for terrestrial and sea-floor mining, and the degree to which environmental externalities are incorporated into the cost of doing business.

4.3.3 The potential non-market costs associated with deep sea mining

It is possible that deep sea habitats, ecosystems, and organisms have value that is not associated with direct use, including the value people place on simply knowing they exist (existence value), the value of saving these deep sea areas for future users (bequest value), and the value of future potential uses for these deep sea areas (option value). Such values depend, in part, on our understanding of the ecosystems, and some recognition of potential future uses (for example, biotechnologies, medical applications, recreation sites, linkages to proximate benthic and pelagic ecosystems, etc.) may be warranted. Our knowledge of these systems and of the options for potential future use is likely to grow rapidly with further exploration and research.
Deep sea mining will cause direct physical changes in the structure of the seabed, as well as in the quality of the physical environment and the nature of environmental processes in the immediate vicinity (see Volume 1 of this series). Mining of sea-floor massive sulphides and cobalt-rich ferromanganese crusts might require strip-mining techniques that use remotely operated underwater cutters to remove the ore. Manganese nodule mining might use a vacuum system. Strip mining and sea-floor vacuuming could destroy the physical habitat of deep sea-floor areas and associated biota (see Elements of Production, below). Without careful controls, deep sea mining could release particulate matter into the water column, both from the cutting process and from the return of turbidity-laden seawater from the shipboard dewatering process (Hoagland et al 2010). This release could be detrimental to organisms living close to the mine site, and potentially also those farther away.

Access to some parts of the sea may be diminished if deep sea mining activity at the lift/riser site requires a management or exclusion zone. Similar access restrictions could occur due to the marine traffic associated with support vessels. Noise, sediments, and other associated factors could create a de facto exclusion zone. Displacement of artisanal or industrial fishing would result in a further cost associated with mining activities.

Mining might also affect nearby organisms through the introduction of invasive species, toxic substances from the deposit, spilt ore, and such pollutants as hydraulic fluids, noise, and vibration. In addition, mining introduces light into an otherwise dark world, which could potentially interfere with the feeding and reproductive behaviour of organisms (Nautilus Minerals 2008).

Getting marine minerals from the sea floor to market requires a production chain that could affect a wide range of environments, not only those directly associated with the deposit. Onshore operations, which may include infrastructure development, ore transfers, crew transfers, and minerals processing and transport, have the potential to affect local water and air quality and result in carbon emissions. A reduction in local environmental quality could also pose a public health risk to local communities. The potential economic costs of these environmental damages have not yet been estimated.

It should also be recognized that some environmental damage may have only a small impact on societal well-being.
In order to reduce the potential environmental impacts of mining, deep sea mineral extractors will likely be compelled to follow the industry’s Code for Environmental Management of Marine Mining (IMMS 2011). Governments and the International Seabed Authority will require that the mining company and its partner organizations undertake steps to mitigate and reduce environmental impacts. For instance, a recent publication by the International Seabed Authority (Van Dover et al. 2011) on the environmental management of deep sea chemosynthetic ecosystems put forward guidelines (the Dinard Guidelines) aimed at protecting the natural diversity, ecosystem structure, function, and resilience of chemosynthetic ecosystems, while enabling rational use. While efforts to reduce environmental impacts may result in savings by avoiding losses in ecosystem services, many such environmental protection activities represent real economic costs that must also be considered in weighing the potential value of deep sea mining.

The potential economic benefits and costs of deep sea mining affect the overall level of wealth injected into a country. At the same time, the generation of market values (revenues and financial costs) can be expected to create knock-on effects throughout the economy.

Revenue generated from deep sea minerals could allow national governments to provide services previously out of financial reach, such as new hospitals, schools, or roads. In so doing, local engineering firms, contracted to do the work, might be expected to employ new staff. These workers would then have money to buy food and pay for housing in the community. With increased sales revenue and housing costs, local businesses might experience a small boom, and they in turn might take on additional staff who would buy more products.

In this way, the market benefits of deep sea mining (earnings and investment) can spread throughout the national economy.

However, not all economic impacts of deep sea mining are likely to be beneficial. First, macro-economic ripple effects generated from deep sea mining will only be sustainable for as long as the national benefits of deep sea mining exceed the national costs. Even industries running at a loss can maintain employment and support local shops and service industries while money is pumped into them. However, income pumped into failing industries will be deflected from other industries where national benefits might be higher than costs and where positive ripple effects could be generated without support. As a result, continuing investment in the sector, if deep sea mining is unprofitable, would likely occur at the expense of other areas of the economy. Further, where national costs exceed benefits, the industry represents a drain on national resources, and sooner or later the money will run out. At this point, rather than supporting sections of the economy, these sections would suffer negative ripple effects, contracting, shrinking, and potentially closing.

In contrast, where the national benefits of deep sea mining exceed their costs, new wealth is created in the economy, and the associated macro-economic growth can be sustainable – depending on how it is used and its investment in social and economic capital, as indicated earlier.
Pacific Island states will need to make decisions about whether the potential benefits of deep sea mining, both within their national jurisdictions and beyond, exceed the costs. When, for example, might revenues be sufficient that some level of environmental damage would be acceptable? And what is the threshold for acceptable versus unacceptable levels of environmental damage?

Even a full accounting of costs and benefits might not tell policy makers in the Pacific whether deep sea mining is in the best interests of the state or region. It is critical to understand which costs and benefits will be felt by the Pacific Island states and which will be enjoyed abroad. Methods are needed to compare the potential costs and benefits of deep sea mining — to weigh the costs and benefits outlined above, but also to assess these impacts in the context of other societal, cultural, and development goals.

4.5.1 Benefit-cost analysis

Benefit-cost analysis is now a requirement of most major development projects. It is a framework used to assess the economic merits of an activity from the perspective of society. It involves:

- calculating the gains and losses (benefits and costs) from an activity to the community (or state), using money as a measure; and
- aggregating values of gains and losses and expressing them as net economic value (benefits less costs) (Pearce and Turner 1990).

In benefit-cost analysis, costs and benefits are organized both by year and over time to determine the aggregate economic impact of a project. This impact is represented in terms of net present value, which places greater weight on costs and benefits generated in the present than in the future, or internal rates of return, which show the relative proportion of benefits compared to costs (Figure 4.6).

Traditionally, benefit-cost analysis has focused on the direct financial costs and benefits of a project, adjusted to account for taxes, subsidies, and other market distortions. More recently, the approach has been expanded to include opportunity costs, including environmental costs, like those discussed earlier in this chapter (see Pricing Nature by Hanley and Barbier (2009)). Including opportunity costs provides a more complete accounting of the combined direct and indirect (external) costs and benefits — those that are reflected in the market and those that are not. Indirect and non-market estimates of costs and benefits, however, are not always easy to quantify, and the estimates used in a benefit-cost analysis may reflect this imprecision.

Benefit-cost analysis can also be used to show how the costs and benefits of a project are distributed across different businesses, organizations, individuals, or communities. This is known as distributional analysis. A distributional analysis is likely to be especially useful when designing programs to reinvest mining taxes/fees/royalties in social capital or when trying to identify stakeholder groups that are likely to support or challenge deep sea mining plans.
Benefit-cost analysis, however, does not provide a direct comparison between economic considerations and other social, political, or cultural goals or considerations. Other mechanisms, such as multi-criteria analysis, strategic environmental impact assessment, or life cycle thinking, may offer a better way of weighing the societal impacts of deep sea mining.

### 4.5.2 Multi-criteria analysis

Multi-criteria analysis is a decision-making tool that allows for the comparison of a variety of impact measures – economic, social, cultural, political, and biological – associated with a proposed project. This approach can be useful in a situation such as deep sea mining, where a complete economic accounting of project impacts on ecosystems and people might not be feasible.

### 4.5.3 Life cycle thinking

Life cycle thinking provides an important lens through which to view potential impacts throughout the life of a process – from the extraction of resources to the production of final goods and services (known as a “cradle to grave” approach). The impacts considered by life cycle thinking include those that occur locally, nationally, regionally, and globally.

As applied to deep sea mining, a life cycle approach would include impacts associated with exploration, commissioning, extraction, transport and processing, entry to market, integration in production of products, consumption of final products, and end of life, including reuse or redesign of mining infrastructure, as well as of products in which the minerals are utilized, when possible.

### 4.5.4 Strategic environmental assessments

Perhaps the most comprehensive tool to weigh deep sea mining’s contribution to broader national development and environmental goals is the strategic environmental assessment. Strategic environmental assessment is a tool designed to achieve sustainable development by promoting dialogue, mutual understanding, and trust among stakeholders from the grass roots to high-level decision-makers. Unlike environmental impact assessment, strategic environmental assessment does not focus on one specified activity at one site, but takes a broader industry/marine space-wide approach (see Figure 4.7 for further comparison). The strategic environmental assessment process aims to ensure that the policies and national plans underpinning the development of extractive sectors take other users of land, sea, air, water, and other shared environmental assets into account within a coherent national development agenda. Strategic environmental assessment would be part of a transparent process, with the aim of ensuring that all stakeholders – governments, civil society, and the private sector – are involved in the planning of deep sea mining.

Strategic environmental assessment has been used in industrialized countries for years to provide a frame of reference for the development of national and regional plans and programs (Figure 4.8). It has gained support from governments and civil society groups in the Pacific (DEAT 2007), as well as from such development partners as the World Bank and the Organisation for Economic Co-operation and Development (OECD) (Kjörven and Lindhjem 2002; OECD 2006). In the European Union, strategic environmental assessment has become a legally enforced procedure required by Directive 2001/42/EC, which aims to ensure systematic assessment of the environmental effects of strategic land-use-related plans and programs.

---

**Toolbox for life cycle thinking**

Life cycle assessment: a technical tool designed to apply the concepts of life cycle thinking to the potential environmental impacts of a product or service. The criteria for a life cycle assessment are defined through the ISO 14040 series.

Social life cycle assessment: an assessment of the social implications or potential impacts of a good or service.

Life cycle costing: the sum of all economic costs over the full life cycle (or a specified period) of a good or service. This can include the costs of purchase, installation, operation, and maintenance, and estimated value at the end of its defined life cycle. (ISO 15600 series)

Design for the environment: an analysis of three main design objectives: design for environmental processing and manufacturing; design for environmental packaging; and design for disposal or reuse. (Multiple ISO standards cover this approach, contingent on application.)

Eco-labelling: a communications tool to help consumers and businesses make more informed decisions. (Four main categories of labels and their associated criteria are defined through the ISO 14020 series.)

### Difference between EIA and SEA

<table>
<thead>
<tr>
<th>Environmental Impact Assessment of projects</th>
<th>Strategic Environmental Assessment of strategic initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Technical instrument related to activities</strong></td>
<td><strong>A Political instrument related to concepts</strong></td>
</tr>
<tr>
<td><strong>with geographic and technical specifications</strong></td>
<td></td>
</tr>
<tr>
<td><strong>A Reactive approach</strong></td>
<td><strong>A Proactive approach</strong></td>
</tr>
<tr>
<td><strong>- at the end of the decision-making process</strong></td>
<td><strong>- at earlier stages of the decision-making process</strong></td>
</tr>
<tr>
<td><strong>Identifies specific impacts in the environment</strong></td>
<td><strong>Addresses issues of sustainable development</strong></td>
</tr>
<tr>
<td><strong>Limited review of cumulative effects</strong></td>
<td><strong>Gives early warning of cumulative effects</strong></td>
</tr>
<tr>
<td><strong>Emphasis on mitigating and minimizing impacts</strong></td>
<td><strong>Prevention in terms of identified environmental objectives</strong></td>
</tr>
</tbody>
</table>

Least strategic ‚ Most detailed ‚ Most strategic ‚ Least detailed

**Figure 4.7** Environmental impact assessment (EIA) and strategic environmental assessment (SEA) as part of a decision-making process.
Integrating the environment into decision making

Figure 4.8 Integrating the environment into decision making using SEA.
Deep sea mining is technologically, politically, and legally complicated. It is an evolving and extremely costly endeavour. As a result, the economic decisions associated with deep sea mining are intertwined with political factors and other economic considerations that are only indirectly related to a proposed mining project. For instance, international aid, diplomatic concerns, or other political factors may be important elements in whether or not a country decides to grant a concession to a foreign corporation. In the Area, state contracts or sponsorship may have as much to do with the strategic importance of access to minerals as they do with the potential profitability of a mining operation.
Deep sea mining is just one of many possible economic options that Pacific Island states can utilize to meet development goals. Too much dependence on one or a narrow selection of development opportunities exposes a country to economic risks beyond its control.

Other options for green economic development include:
• traditional economic activities, such as artisanal fishing, crafts, and farming;
• greened manufacturing and service sectors;
• reformed commercial fisheries (especially through policies that capture more of the fisheries’ value for use by the state or communities);
• green tourism; and
• payments for the ecosystem services produced by healthy reefs, mangroves, and terrestrial habitats.

To ensure that this portfolio of options meets development needs equitably and sustainably, it is important to consider how new development options, such as deep sea mining, affect other existing and potential options.

Ecological, economic, and social resilience are important considerations when weighing the costs and benefits of deep sea mining, as well as the potential ways in which the proceeds of mining might be reinvested in society.

Tools and analyses – such as benefit-cost analysis, multi-criteria analysis, life cycle thinking, and strategic environmental impact assessments – can help Pacific Island states understand the potential impacts of deep sea mining. These tools can help identify opportunities to make deep sea mining an important part of a green economy.

Key messages

A decision by a state to proceed with deep sea mining requires careful assessments of the broad range of economic and social consequences that could result, and analysis showing that the overall benefits to the country are greater than the potential costs associated with mining.

When feasible, action should be taken to minimize the environmental impacts of deep sea mining, provided that the benefits exceed the costs of doing so.

A green economy can be achieved if an equitable portion of the economic proceeds of deep sea mining are reinvested into other forms of economic, social, and natural capital to ensure that societal well-being is improved and made more sustainable and resilient.
Vanuatu market. Photo courtesy of Ransom Riggs


IMF (2011). The International Monetary Fund country report no. 11/113. The International Monetary Fund, Washington, DC.


SPC (2013). Deep sea minerals: Sea floor massive sulphides, a physical, biological, environmental, and technical review. Secretariat of the Pacific Community.


