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# Sand and Sustainability: 10 strategic recommendations to avert a crisis

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# Sand and Sustainability: 10 strategic recommendations to avert a crisis

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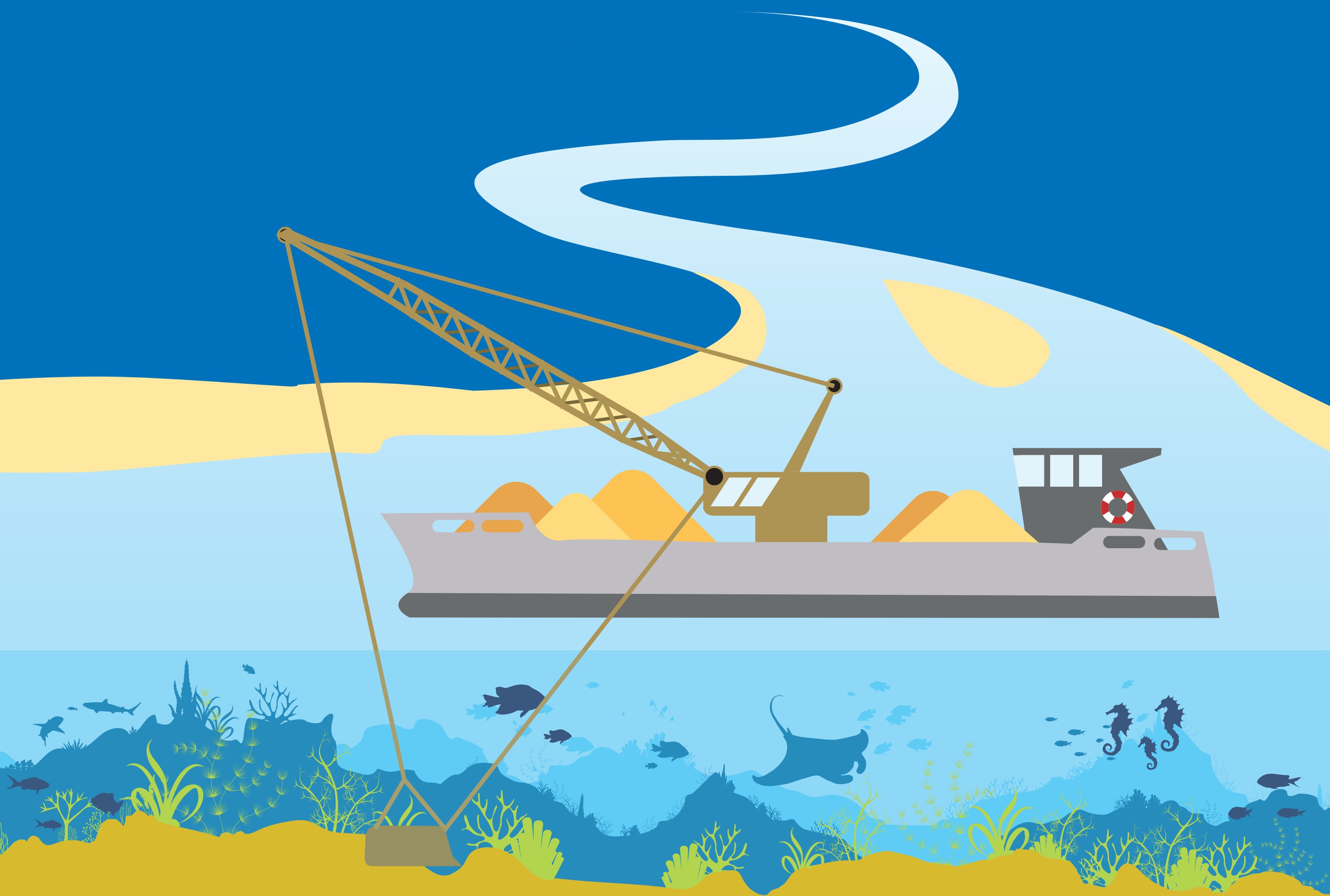

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1 Specific contributions available in the appendix.

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# Foreword

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**For this report, a group of world experts from all sectors was convened to propose 10 solution-oriented recommendations to this impending sand crisis.**

*I encourage all stakeholders, including governments, industry, and civil society to take this opportunity and start the necessary transformations in our institutions, businesses, and societies in how we manage and use sand.*

# Foreword

When the United Nations Environment Programme (UNEP) released its first report on sand in 2014, the issue of sand and sustainability had not received considerable scientific, nor policy, attention at the inter-governmental level. Despite sand being the most used solid material (50 billion tonnes per year), global attention about the sheer scale and impact of sand extraction remains limited.

All countries and most sectors need sand. As this report shows, sand resources play a strategic key role in delivering ecosystem services, maintaining biodiversity, supporting economic development, and securing livelihoods within communities. Indeed, sand is increasingly vital for building the very foundations of our societies: our homes, the schools for our children, the dams and photovoltaic panels to produce renewable energy. Sand is also essential for building the roads, bridges, hospitals, and infrastructure that are key to human development. Sand is thus the unrecognised hero of our development.

The world has been living with easy-to-access sand resources. Consequently, sand is being used faster than it can be replenished by natural geological processes in some locations, while damages to ecosystems is occurring in others. As the global urban population will increase to represent over 68% of the world population by 2050, and as cities expand and urban infrastructure is upgraded, demand for sand will only increase. Yet, sand in the natural environment supports fisheries, biodiversity, protects against coastal erosion and salinisation of aquifers, and serves as a natural filtration of water. Until now we may have considered sand as a common material; it is time to reassess and recognise sand as a strategic material.

We now find ourselves in the position where the needs and expectations of our societies cannot be met without improved governance of sand resources. The sand and sustainability challenge is already being considered by the international community. In 2019, the 4th United Nations Environment Assembly (UNEA-4) adopted UNEA resolution 4/19 on Mineral Resource Governance, which specifically included sand as a topic of concern. At UNEA-5 in 2022, Member States requested for more information on sustainable practices related to, amongst others, sand as a mineral, as acknowledged in the UNEA resolution 5/12 on minerals and metals management. Additionally, the International Union for the Conservation of Nature (IUCN) has called for the urgent global management of marine and coastal sand resources.

For this report, a group of world experts from all sectors was convened to propose 10 solution-oriented recommendations to this impending sand crisis. They include, namely, adopting integrated policy and legal frameworks, mapping sand resources, promoting resource efficiency and circularity, sourcing responsibly and restoring our ecosystems. The overarching purpose of this report is to encourage policy makers at all governance levels to adopt relevant policies and standards, and promote best practices, in tune with local sand dependencies and development imperatives.

If we act now, it is still possible to avoid a sand crisis. I encourage all stakeholders, including governments, industry, and civil society to take this opportunity and start the necessary transformations in our institutions, businesses, and societies in how we manage and use sand.

Sheila Aggarwal-Khan
Director, Economy Division
United Nations Environment Programme

# Abbreviations

**Table 1 : Abbreviations and acronyms**

| Term | Definition |
|---|---|
| BMAPA | British Marine Aggregate Producers Association |
| BRE | Building Research Establishment |
| C&DW | Construction and demolition waste |
| CIDA | Construction Industry Development Authority (of Sri Lanka) |
| DWCRA | Development of Women and Children in Rural Areas |
| DSS | Decision support system |
| EC | European Commission |
| EU | European Union |
| EZZ(s) | Exclusive economic zone(s) |
| EIA | Environmental impact assessment |
| EMSAGG | European Marine Sand and Gravel Group |
| EPFL | École polytechnique fédérale de Lausanne |
| FAIR | Findable, accessible, interoperable, and reusable |
| FIR | Fédération Internationale du Recyclage |
| FOEN | Federal Office for the Environment (of Switzerland) |
| GAIN | Global Aggregates Information Network |
| GESAMP | Group of Experts on the Scientific Aspects of Marine Environmental Protection |
| GHGs | Greenhouse Gasses |
| GMSL | Global Mean Sea Level |
| GRID | Global Resources Information Database |
| GST | Goods and Services Tax |
| IADC | International Association of Dredging Companies |
| ICES | International Council for the Exploration of the Sea |
| IPCC | Intergovernmental Panel on Climate Change |
| IRP | International Resource Panel |
| IUCN | International Union for Conservation of Nature |
| LCA | Life cycle assessment |
| LCI | Life Cycle Inventory |
| LSE | London School of Economics |
| MFA | Material Flows Analysis |
| MPA | Mineral Products Association |
| NbS | Nature-based Solution(s) |
| NetWwater | Network of Women Water Professionals |
| NGO(s) | Non-governmental organisation(s) |
| RSM | River sand mining |
| SLWP | Sri Lanka Water Partnership |
| SMI | Sustainable Minerals Institute (at the University of Queensland) |
| UEPG | European Aggregates Association |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNEA | United Nations Environmental Assembly |
| UNEP | United Nations Environment Programme |

| | |
|---|---|
| UNFC | United Nations Framework Classification |
| UNIGE | University of Geneva |
| UQ | The University of Queensland |
| USA | United States of America |
| USGS | United States Geological Survey |
| WWF | World Wildlife Fund/Worldwide Fund for Nature |
| SDGs | Sustainable Development Goals |
| SEEA | System of Environmental Economic Accounting |
| SFS | Spent Foundry Sand |
| VAT | Value-Added Tax |

# Glossary

Although the issue of the management of sand and gravel resources is gaining international recognition, there are no universally accepted terminology and basic definitions, including of sand itself. It should be noted that the definitions below vary by industry and region.

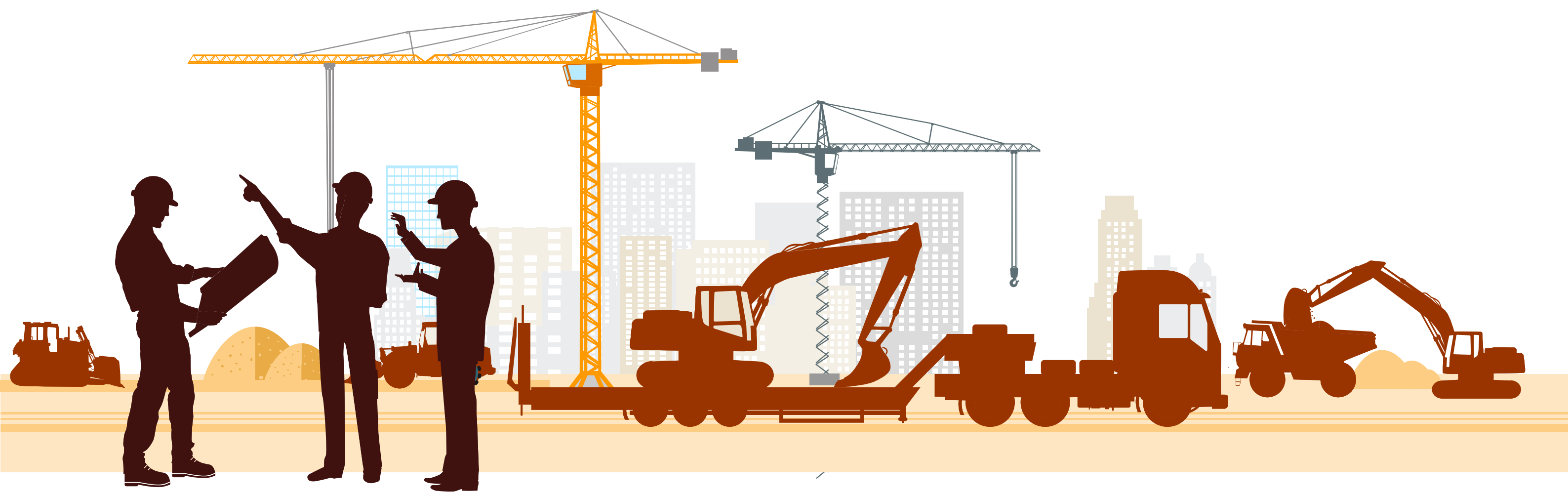
Within the framework of the Global Sand Observatory initiative, UNEP/GRID-Geneva initiated an open-ended review on terms and definitions related to sand resource governance in consultation with a growing network of experts. The terms reviewed in 2021 are presented in (UNEP/GRID-Geneva 2022a) and (UNEP/GRID-Geneva 2022b) and provide further information on the definitions used in this glossary. The terms are presented in alphabetical order.

**Table 2 : Definition of terms used**

| | |
|---|---|
| **Aggregate** | Aggregate is a granular material of natural, processed, or recycled origin used essentially for construction purposes with an upper grain size limit of 75mm (UNEP/GRID-Geneva 2022a). |
| **Primary materials** | Sand, gravel, and crushed rock extracted from the natural environment (UNEP/GRID-Geneva 2022a). |
| **Crushed rock** | A mineral granular material which is the result of mechanical crushing of rock. Crushed rock usually also involves screening and possibly washing. |
| **Circular economy** | An economic system in which products and materials are designed in such a way that they can be reused, remanufactured, recycled or recovered and thus maintained in the economy for as long as possible, along with the resources of which they are made, and the generation of waste, especially hazardous waste, is avoided or minimised, and GHGs are prevented or reduced (UNEP/EA.1/Res.1). |
| **Development Minerals** | Minerals and materials that are mined, processed, manufactured, and used domestically in industries such as construction, manufacturing, infrastructure, and agriculture (Franks 2020). |
| **Efficiency** | Efficiency is a broad concept that compares the inputs to a system with its outputs, essentially achieving more with less in common usage (IRP and UNDP 2017). However different efficiencies are important in different disciplines relevant to sand and gravel sourcing, use and management. |
| **Ecosystem services** | Functions and processes which ecosystems provide, and which affect human well-being. They include (a) provisioning services such as food, water, timber, and fibre; (b) regulating services such as the regulation of climate, floods, disease, wastes, and water quality; (c) cultural services such as recreation, aesthetic enjoyment, and spiritual fulfilment; and (d) supporting services such as soil formation, photosynthesis, and nutrient cycling (Millennium Ecosystem Assessment 2005). |
| **Environmental impact assessment** | The assessment of the consequences of a plan, policy, program, or major projects prior to the decision to move forward with the proposed action. Both environmental and social aspects can be considered to complement cost-based assessments. EIA is a well-established assessment framework in infrastructure projects (e.g., for dams, motorways, airports, or factories). |
| **Extraction rates** | The rate at which sand resources are removed from the natural environment by volume over time. |
| **Governance** | The on-going interaction and co-evolution between public and/or private entities with the purpose of realising a collective interest. This process can vary in its level of institutionalisation, collaboration, and ability to adapt to change. The collective interest in the context of responsible sourcing and use of sand and its alternatives include human wellbeing, environmental quality and economic performance being maintained or enhanced equitably for resilience (Cairney 2021). |

| | |
|---|---|
| **Gravel** | A mineral granular material which does not stick together when wet and remolded (i.e., non-cohesive) and where the combined weight of 50% of the particles is larger than 4.75mm but smaller than 75mm with less than 15% of material smaller than 75µm. For a precise and correct description of gravel, it is highly recommended to use secondary qualifiers (UNEP/GRID-Geneva 2022a). |
| **Inactive sand bodies** | A deposit of sand that lies outside of the influence of modern erosional and depositional processes. In geological terms, these sediments can be described as relict or fossil. |
| **Life cycle assessment** | The evaluation of the expected environmental and social impacts of a product, service, or any other type of system (company, region, country). LCAs, also called footprints, provide a systemic perspective considering the full extraction-production-consumption chains needed to deliver a service. They consider multiple indicators including climate-change, biodiversity loss, eutrophication, impacts on human health, water use and scarcity, resource use, etc. |
| **Marine sand** | Sand derived from near- and offshore deposits, beaches, bays, and lagoons (UNEP/GRID-Geneva 2022a). |
| **Natural/green infrastructure** | Refers to a strategically planned and managed network[s] of natural lands, such as forests and wetlands, working landscapes, and other open spaces that conserves or enhances ecosystem values and functions and provides associated benefits to human populations (UNEP 2021c). |
| **Naturally occurring sand** | Sand sourced from the natural environment, which does not include crushed rock. |
| **Nature-based Solutions** | Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. (IUCN 2016). |
| **Ore-sand (O-sand)** | A type of processed sand sourced as a co-product or by-product of mineral ores. Typically, it is a result of mechanical crushing and grinding, different physical and physicochemical beneficiation processes for mineral concentrates recovery, including optimisation of these processes and additional processing stages to achieve the required properties of sand. (Gallagher et al. 2021 ; Golev et al. 2022). |
| **Policy** | Policy is difficult to define particularly across the varied domains that are core to sand and sustainability. The term can mean : a domain of interest ; an intended outcome or proposal for action by any policy actors ; formal decisions taken by government, private sector or other policy actors or the process to take such decisions ; government plans, programs, legal frameworks, or legislation (Cairney 2019). |
| **River sand** | Sand derived from river channels, estuaries, deltas, and river floodplains (UNEP/GRID-Geneva 2022a) but does not cover sand sourced from lakes (lacustrine sand). |
| **Sand** | A mineral granular material that does not stick together when wet and remoulded (i.e., non-cohesive) and where the combined weight of 50% of the particles is smaller than 4.75mm, with less than 15% of material smaller than 75µm. For a precise and correct description of sand, secondary qualifiers are highly recommended (UNEP/GRID-Geneva 2022a). |
| **Sand extraction** | The removal of primary (virgin, natural) sand resources from the natural environment (terrestrial, riverine, lacustrine, coastal, or marine) (UNEP 2019). Sand can be removed for infrastructure works without the objective of using it as a resource (e.g., the construction of a channel). |
| **Sand mining** | The removal of primary (virgin, natural) sand resources from the natural environment (terrestrial, riverine, lacustrine, coastal, or marine) as a resource for subsequent processing or use. |
| **Sand resources** | An abbreviation used to denote sand, gravel, crushed rock, and aggregates. [Also used as: Global sand resources]. |
| **Scale** | Scale refers to spatial, temporal, jurisdictional, institutional, management, networks, knowledge scales. 'Level' refers to the different units of analysis possible in each of these scales (Cash et al. 2016). |

| | |
|---|---|
| **Secondary aggregates/ material** | Secondary aggregates/raw materials can include both recycled and reused aggregates and material (UNEP/GRID-Geneva 2022a). |
| **Silica sand** | Sand with a high silica concentration fit for industrial uses (UNEP/GRID-Geneva 2022a). |
| **Sustainability** | Sustainability means transforming our ways of living to maximise the chances that environmental and social conditions will indefinitely support human security, well-being, and health (UNEP 2019). |
| **Sustainable development** | Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Brundtland Commission 1987). |
| **Sustainable infrastructure** | Any infrastructure that is planned, designed, constructed, operated, and decommissioned in a manner that ensures economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire infrastructure lifecycle (UNEP 2021c) |
| **Sustainable sand management** | Ensuring that (a) consumption does not exceed levels of sustainable supply and (b) that the earth 's systems are able to perform their natural functions (e.g., that sediment flows in river basins continue). The objective is to ensure the long-term material basis of societies in a way that resource extraction, use, and waste and emissions management do not surpass key thresholds for long-term environmental sustainability and human wellbeing (UNEP 2019). |
| **Sustainable sand supply** | Amount of resources that can be extracted and used for production and consumption before the threshold of a safe operating space is surpassed (UNEP 2019). |



# Executive Summary

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# Executive Summary

Sand plays a strategic role in delivering ecosystem services, maintaining biodiversity, supporting economic development, and providing livelihoods within communities. It is linked to all 17 Sustainable Development Goals (SDGs) either directly or indirectly. Despite the strategic importance of sand, its extraction, sourcing, use, and management remain largely ungoverned in many regions of the world, leading to numerous environmental and social consequences that have been largely overlooked (Peduzzi 2014 ; UNEP 2019).

"Sand and Sustainability : 10 strategic recommendations to avert a crisis" therefore consolidates the expertise in sand and sustainability from different sectors to bring attention to the impacts from the current state of extraction, use and (mis)management, putting forward recommendations for actions to set the global sand agenda in addressing environmental sustainability needs alongside justice, equity, technical, economic, and political considerations.

## The Case for Better Governance & Management of Sand Resources

The sand and sustainability challenge is undoubtedly complex; real solutions will need to be cross-sectoral, and in some cases cross-border, where immediate actions across all scales of governance are needed to avert a global crisis.

A holistic approach that covers the entire value chain of the sector is therefore required. As such, these 10 recommendations are organised under three broad levels:

- **Setting the overarching agenda - Recommendation 1 to 3** are principles for the overall governance of sand resources. Recognising and formalising sand as a strategic resource at all levels of government and society is a crucial step in the transition towards sustainable sand resource governance and management. Similarly, a place-based approach and the participation and inclusion of all people in decision making are crucial, and necessary to avoid the pitfalls of one-size-fits-all solutions. Breaking down silos and promoting diverse materials, methods and models are necessary for the paradigm shift towards a circular future. Together, they provide a collective vision that could be conferred with institutional (through law or policy) and perceived legitimacy (stakeholder agreement).
- **Setting the (right) institutional and legal structure - Recommendation 4 and 5** propose changes to governmental and legal structures through integrating policy and legal frameworks horizontally, vertically and intersectionally to manage sand resources, and creating an effective mineral ownership and access framework (extending onshore and offshore) that will also allow for a locally acceptable commercial mechanism for cost recovery.
- **Implementation - Recommendation 6 to 10** are instruments that are vital in managing sand as a resource; from mapping, monitoring, and reporting sand resources to putting together best practices and national standards, and a coherent international framework; from promoting innovation and experimentations with new ways to substitute sand, and responsible sourcing, to advancing knowledge and practices that could restore ecosystems and compensate for remaining losses.

It is important to note that these three levels of recommendations reinforce one another, driving towards governance that should be effective, equitable, responsive, and robust (Bennett and Satterfield 2018).

**The following ten recommendations offer guidance on how sand resources should be governed and managed in a responsible, sustainable, and just manner ：**

| Table 3 : 10 Recommendations to Avert a Crisis | |
|---|---|
| **Recommendation 1** | **Recognise sand as a strategic resource** that delivers critical ecosystem services and underpins the construction of vital infrastructure in expanding towns and cities globally. |
| **Recommendation 2** | **Include place-based perspectives for just sand transitions**, ensuring the voices of all impacted people are part of decision-making, agenda-setting and action. |
| **Recommendation 3** | **Enable a paradigm shift to a regenerative and circular future**. |
| **Recommendation 4** | **Adopt strategic and integrated policy and legal frameworks** horizontally, vertically and intersectionally, in tune with local, national, and regional realities. |
| **Recommendation 5** | **Establish ownership and access to sand resources** through mineral rights and consenting. |
| **Recommendation 6** | **Map, monitor and report sand resources** for transparent, science-based and data-driven decision-making. |
| **Recommendation 7** | **Establish best practices and national standards, and a coherent international framework** |
| **Recommendation 8** | **Promote resource efficiency & circularity** by reducing the use of sand, substituting with viable alternatives and recycling products made of sand when possible. |
| **Recommendation 9** | **Source responsibly** by actively and consciously procuring sand in an ethical, sustainable, and socially conscious way. |
| **Recommendation 10** | **Restore ecosystems and compensate for remaining losses** by advancing knowledge, mainstreaming the mitigation hierarchy, and promoting nature-based solutions. |

# Introduction

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## Impact of sand extraction

In general, extraction of *inactive* sand deposits is unlikely to cause impacts beyond immediate physical disturbance. In contrast, extraction from *active* sand bodies resulting in changing rates of sand transport (e.g., in rivers or in coastal and nearshore marine zones) could lead to erosion threatening communities and livelihoods – not just at the point where extraction is occurring, but also downstream in the affected system.

# Introduction

Sand, gravel, crushed stone and aggregates (hereinafter 'sand resources') are the second most exploited natural resource in the world after water, and their use has tripled in the last two decades to reach an estimated 40-50 billion metric tons per year (UNEP 2019), driven by factors such as urbanisation, population growth, economic growth, and climate change.

Sand resources play a strategic role in delivering ecosystem services, maintaining biodiversity, supporting economic development, as well as securing livelihoods within communities. Sand is the key raw material in the concrete, asphalt and glass that build our infrastructure. It is also used for land reclamation as well as flood protection in coastal areas, as efforts are ramping up to protect eroding coasts and address climate change impacts such as sea-level rise and increasingly severe storms. Satisfying a growing sand demand without transgressing planetary boundaries represents an important and insufficiently recognised sustainability frontier (Torres et al. 2021).

## Box 1 - Active or inactive sand bodies: Differences in impact

On a geological timescale—over thousands and millions of years—naturally occurring sand has been continually moved as sediments around the surface of the earth. Again and again, sand has been eroded, deposited, and transported across the land surface, through our river systems, and around the marine environment by natural physical processes (e.g., winds, water currents and tidal flows). Where the energy of those natural physical processes is high enough to mobilise the grains, sand can be eroded and transported. Sand is then deposited as accumulations—sand bodies—in areas where the energy of the processes transporting them declines[2].

Tectonic forces and changes in global climate have resulted in the continuous and widespread movement of substantial volumes of naturally occurring sand. For example, over the past few million years there have been significant shifts in the location and intensity of erosional and depositional processes, largely arising from repeated global cold phases ('ice ages'). Ensuing glaciations and marked changes to sea-level and rivers have redistributed naturally occurring sand into the complex configuration of sand bodies we observe today.

While the erosional and depositional processes remain ongoing, on a human timescale, sand bodies can be considered *inactive* or *active*. *Inactive*[3] sand bodies are static and lie outside of the influences of the present-day sedimentary regime. In contrast, where sand bodies are subject to modern erosional and depositional processes, they can be considered active and dynamic. Some environments where active sand movement occurs are more dynamic (e.g., estuaries, rivers, deltas, deserts, and beaches), while others represent lower energy regimes (e.g., the offshore marine environment).

Globally, sand bodies form an integral part of the landscape and ecological system, contributing to biodiversity and our living environment. Until recently the landscape and natural balance of continual erosion and deposition of sand has been largely unaffected as sand could flow freely and was extracted at relatively low levels from *both inactive and active* sand bodies. However, the rapid growth in demand for sand resources and the localised buildup of sediment caused by infrastructure (e.g., by hydropower dams) have increased the threat to these systems. Unless properly managed, the significant short-term impacts arising from the increase in scale and rate of sand extraction can tip the natural balance, resulting in potentially critical social, economic, and environmental impacts.

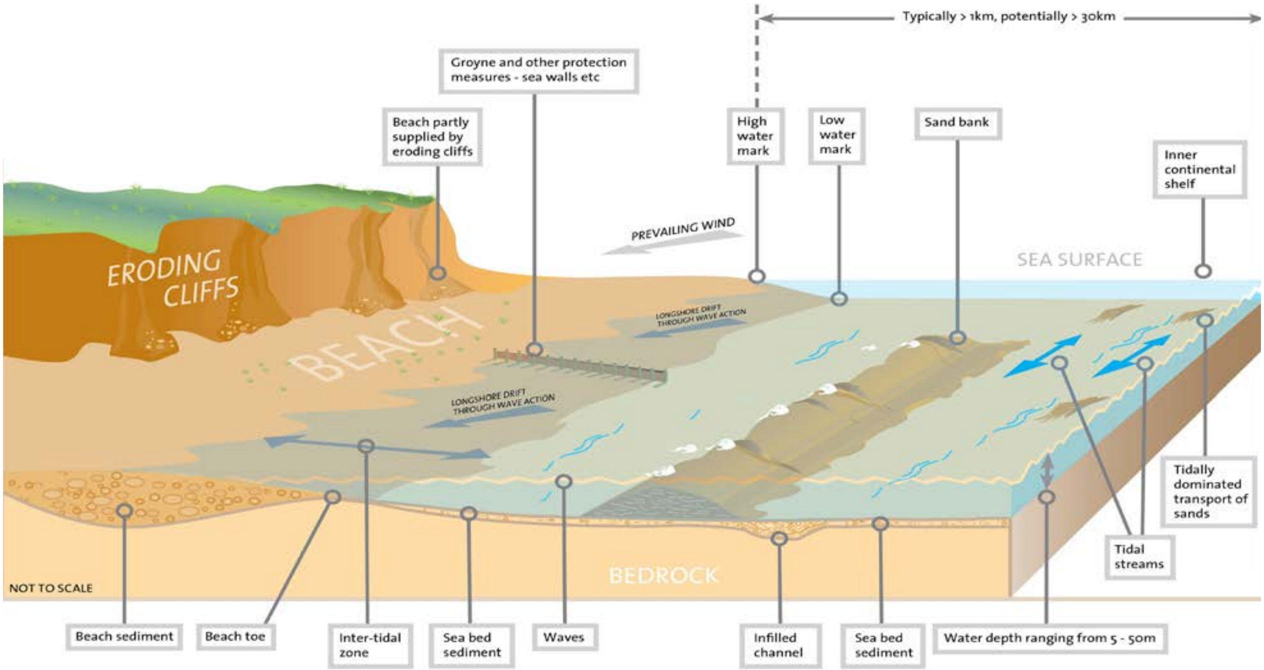
Recognising sand as an integral component of the landscape and environmental system and understanding the processes controlling sand distribution (Figure 1) is the first step towards sustainable management. For example, in general, extraction of *inactive* sand deposits is unlikely to cause impacts beyond immediate physical disturbance. In contrast, extraction from *active* sand bodies resulting in changing rates of sand transport (e.g., in rivers or in coastal and nearshore marine zones) could lead to erosion threatening communities and livelihoods – not just at the point where extraction is occurring, but also downstream in the affected system.

Extraction from active sand bodies therefore requires careful assessment, mitigation, and management. In summary, understanding the geological origin of sand bodies and the modern-day natural processes, and acting upon them, is critical to the success of their sustainable extraction.

2 Alongside naturally occurring sand, coarser sediments, ranging from gravels to boulders, could also be eroded and transported over great distances before being deposited, where the energy of the physical processes acting upon them is high enough.

3 In geological terms, inactive sand bodies may be described as relict or fossil – deposited in past depositional environments and preserved.

**Figure 1: Key features and processes considered in a coastal impact study for aggregate dredging**




Source: (BMAPA and The Crown Estate 2013 p.41)

## The Sand and Sustainability Challenge: An Impending Crisis

Despite sand's strategic importance, its extraction, sourcing, use, and management remain largely ungoverned in many regions of the world, leading to numerous environmental and social consequences that have been mostly overlooked (Peduzzi 2014 ; Bendixen et al. 2021).

Current extraction exceeds the replenishment rates of naturally occurring sand (John 2009 ; Hackney et al. 2021). Sand extraction from dynamic systems, such as riverine and active marine ecosystems, leads to significant environmental impacts, including coastal and river erosion, shrinking deltas, land-use changes, air pollution, salinisation of coastal aquifers and groundwater reserves, threats to freshwater and marine fisheries and biodiversity (UNEP 2019).

Beyond damaging threatened ecosystems, growing demand is triggering socio-economic conflicts (see Box 2) and is fueling concerns over sand shortages (Torres et al. 2017). Sand is mined by a wide range of actors, from large formal companies to informal artisanal and small-scale miners, who often mine in circumstances of poverty, as a cash-in-hand livelihood source. Governance is integral to the sand and sustainability challenge. Sand extraction is unregulated and under-regulated in many parts of the world. In weak governance settings some sand actors have exploited the absence of regulation and oversight to control markets through coercion and even violence. Meanwhile, miners and communities face health and safety risks from drowning (of workers removing sand from riverbeds), subsidence and landslides, amongst other hazards (Awaaz Foundation 2017).

Yet, future urbanisation and massive infrastructure development and maintenance will only further intensify our demand for sand, increasing sand market prices and the construction industry's ecological footprint[4]. Decisive actions are therefore urgent, particularly in the context of anticipating climate-change impacts (IPCC 2021), biodiversity loss (Koehnken and Rintoul 2018) and infrastructure-driven programmes to support critical industries after COVID-19. These economic recovery packages and policies will involve significant investments in infrastructure to stimulate the economy (UNEP 2021a), and therefore represent a crossroads: business-as-usual that is inevitably leading to an environmental, social and economic crisis, or an opportunity to rethink sand extraction and sourcing practices, including a move towards a circular future through substitution with other material and the inclusion of sand into sustainable infrastructure standards.

4 Sand is a constituent component of concrete production, alongside cement, water and coarse aggregates. The cement industry is responsible for around 7 to 8% of global GHG at a lower bound (UNEP 2010).

## Box 2: Sand & Gender

Gender participation in the mining of sand resources is highly context dependent, varying from country to country (Bendixen et al. 2021). The sector creates paid employment and contributes to the financial independence of both men and women, yet it has, in certain contexts, given rise to gender inequalities. These inequalities are particularly pronounced in the distribution of benefits (e.g., jobs, revenues) and its impacts (e.g., effect of siltation on downstream water users) (UNDP 2018b).

**Distribution of benefits** - In Uganda, women represent 70% of crushed rocks and aggregate miners, whereas in Fiji this number is only 6% (UNDP 2018a; UNDP 2018b). Often men undertake the heavy jobs whereas women are responsible for labour-intensive work (Lahiri-Dutt 2008). Although the sand extraction sector provides opportunities for employment and financial independence to women, a large pay gap exists between women and their male peers.

**Impacts of sand mining** - As women's livelihoods—both subsistence farming and financial income—are often more dependent on the land, e.g., through collecting vegetables and shrubs, environmental degradation from sand mining leads to soil infertility and eventually increases food insecurity. Simultaneously, women in a majority of households in rural communities are responsible for collecting water and wood for fuel. As sand mining in riverbeds leads to soil erosion, groundwater salinization and the destruction of vegetation, women have to walk longer distances in search of water and wood for fuel, as reported in Kenya, Uganda and Tanzania (Global Alliance for Green and Gender Action 2018). In some instances, women reported displacement as access to these resources become impossible and the land on which they have lived for generations become inhabitable (ibid.)

**Looking ahead** - Women's high participation in the sand mining workforce highlights the importance of this sector in providing opportunities for paid employment and the significance of women's contributions to economic development, but also the need for targeted measures to rectify inequalities in the extractive and mining sector.

## International Dialogue

The impacts of the unsustainable extraction, management and use of sand have recently started to gain international recognition. The resolution on mineral resource governance (UNEP/EA.4/Res.19) adopted at UNEA-4 specifically recognises the findings of the report by UNEP/GRID-Geneva - "Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources" (UNEP 2019). This recognition of the sustainability challenges related to sand is also highly relevant to the resolution on sustainable infrastructure (UNEP/EA.4/Res.5), as sand is a major resource for construction materials used in infrastructure, including concrete, as well as the latest UNEA-5 resolution on minerals and metals management (UNEP/EA.5/Res.12).

The strategic importance of sand was further highlighted through the adoption of a motion by the IUCN in 2020, calling 'for the urgent global management of marine and coastal sand resources' (IUCN 2020a). UNEP's "International Good Practice Principles for Sustainable Infrastructure" further underlined sand's importance in the context of minimising resource use, closing material loops and incorporating sustainability into public procurement (UNEP 2021b).

In light of the momentum on the international stage and rising pressure from the ground, UNEP/GRID-Geneva carried out a consultation process between 2019 and 2021, engaging with policy actors, scholars and practitioners that lead to the production of the current report. "Sand and Sustainability: 10 strategic recommendations to avert a crisis" consolidates the expertise in sand and sustainability from different sectors, putting forward recommendations for actions by governments and all key stakeholders (Table 4) to set the global sand agenda in addressing environmental sustainability needs alongside justice, equity, technical, economic and political considerations.

While immediate and deliberate actions are necessary, these recommendations should nonetheless **1) work within the local realities of sand resource availability and development imperatives; and 2) help identify the strategic opportunities for cooperation and innovation in how we govern access to and the use of sand resources.**

**This report therefore aims to :**

- **Raise awareness** around the world on sand extraction and use, and its related impacts.
- **Urge policymakers** to explore and adopt policies on sand extraction and use that are appropriate to their contexts and jurisdictions.
- **Shape common goals** across sectors that will help achieve just and responsible sand governance and management everywhere.
- **Propose solutions** for finding pathways toward a more sustainable use of sand. Findings from this report can serve to inform decision-making and support actions at intergovernmental level, in line with a responsible and just management of sand resources.

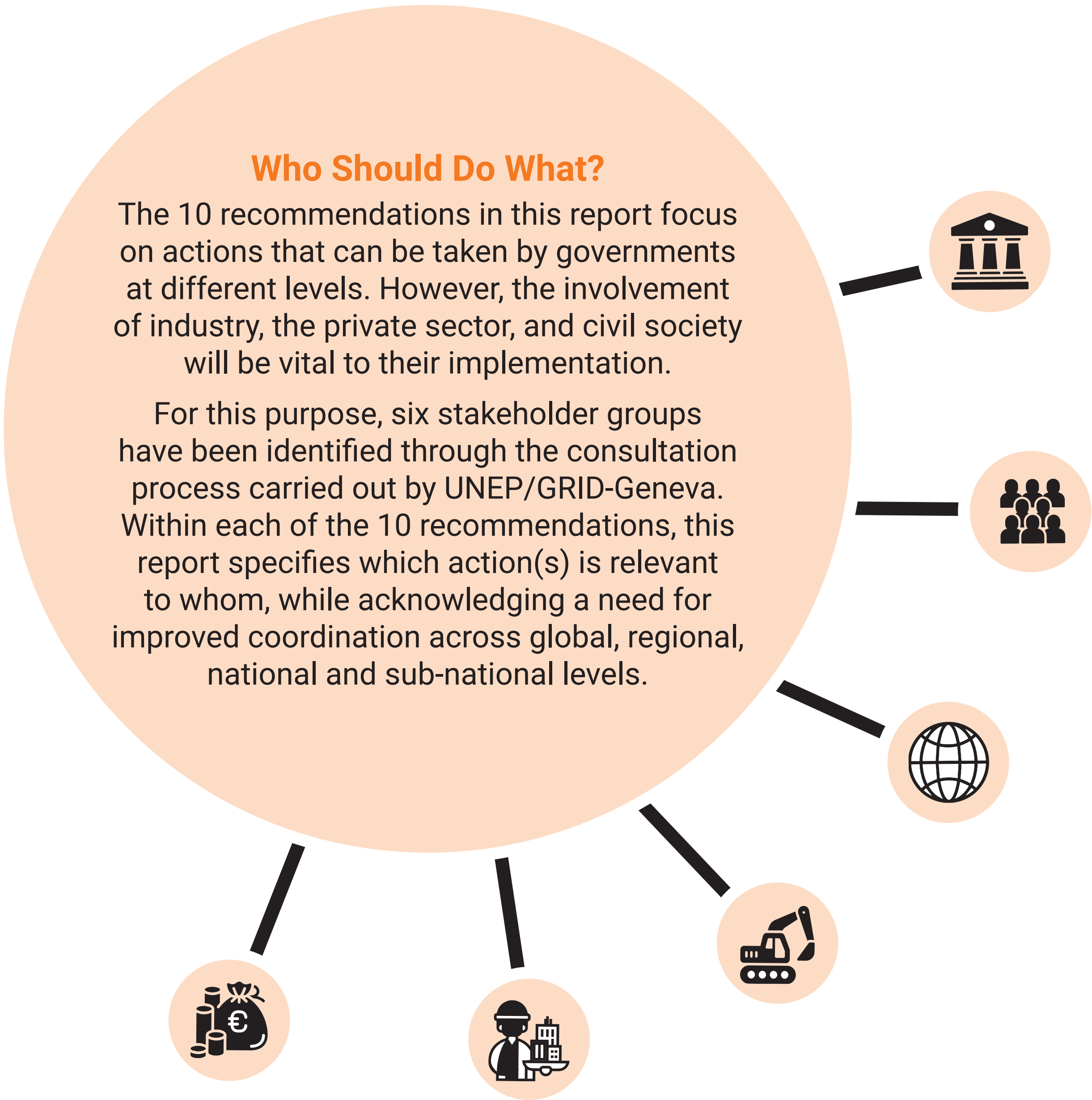


**Table 4 : Relevant stakeholders in sand and sustainability**

| Stakeholder group | Relevance | Who |
|---|---|---|
| Governments/ Public Authorities | Responsible for the natural resources, and mining and extractive industries at the national, municipal and/or sub-national scale. They also influence local livelihoods and (equitable) development pathways, implement environmental and social protection laws, and national monitoring and reporting efforts. | National governments<br>Municipal/sub-national governments and line ministries (local land and spatial planning, economic development, water management, fisheries management, buildings)<br>Law enforcement (e.g., local police force)<br>Village chiefs |
| Civil Society | Organisations and groups along the value chain of sand engaging in environmental and social advocacy, peer support, research, education and capacity development, and global awareness raising to support decision-making. They also lead some of the thinking behind best practices and innovation in the sand sustainability challenge. | Local communities, youth, dissenters, activists, CSOs (involved and/or impacted by extraction activities)<br>Education & research institutions<br>Nongovernmental organisations (NGOs)<br>Media |
| International Entities | Organisations involved in norm-setting, knowledge transfer, convening, consensus-building, research, global data monitoring programs. | Inter-governmental organisations<br>Transboundary cooperation platforms<br>Standard-setting and certification bodies |
| Extractive Industry & Sand Producers | Enterprises of different sizes directly engaged in extractive activities in rivers, coastal zones, marine zones, terrestrial sand deposits, quarries, as well as in trading and transporting sand resources for further use. | Primary sand extraction, dredging and production companies<br>Aggregates associations<br>Artisanal and small-scale miners<br>Firms involved in the initial processing and transport of sand resources<br>Recycling industry and producers of substitutes to naturally occurring sand or crushed rock including secondary aggregates, by-products, co-products |
| End-users | Users of sand resources and/or products that use sand. | Commercial material suppliers (e.g., concrete and concrete products)<br>Civil engineering firms engaged in sourcing crushed rock, sand, gravels and using these materials in construction activities.<br>R&D and materials scientists, construction project managers, operations managers, sales support, supply chain managers (at firm level)<br>Architects |
| Infrastructure Procurement & Finance | Entities that fund construction and infrastructure projects, both in the private and public sector, and thus have a say in the procurement of sand resources | Development banks<br>Municipal & national governments<br>Private & industry investors |

# 10

## Strategic Recommendations to Avert a Crisis

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Recommendations

# Recommendation 1 : Recognise sand as a strategic resource


## Summary

Sand is a material that holds significant environmental, social, and economic value and it is central to achieving the SDGs. Yet this strategic value is often overlooked. In the natural environment, sand contributes to maintaining biodiversity and delivers a series of critical ecosystem services[5], including the protection of deltas and coastal zones vulnerable to the impacts of climate change. Simultaneously, sand underpins the construction of vital infrastructure across the world. Nonetheless, such strategic values are often at odds with each other. Faced with increasing demand for infrastructure in many places and the accelerating impacts of climate change, it is crucial that sand is recognised as a strategic material. A recognition as such is the necessary foundation for a just and responsible governance of sand resources.


## Rationale

Sand is an essential building block of human life (as a commodity used in infrastructure, electronics, etc.), of life support functions (ecosystem services) and for maintaining biodiversity (see Figure 2).

Present estimates indicate that we are using 40-50 billion metric tons of sand resources per year, an average of 18 kg per person per day (Peduzzi 2014 ; Beiser 2018). However, this resource is not consumed evenly. Many still live without basic infrastructure, including decent shelter, clean water, regular electricity, safe roads, equipped hospitals, and a space to learn or work. Achieving the SDGs will require the building of vast infrastructure, for which sand will be crucial[6]. Silica sand is also essential in the building of the green economy, e.g., for the production of solar panels and renewable energy infrastructure, while climate change adaptation efforts also require infrastructure investment to protect against intensifying risks, like coastal erosion, and rebuilding will increase following severe weather events and relocation of people away from risk-prone areas. The need to build becomes even stronger in emerging COVID-19 recovery plans, which centre infrastructural investment as a cornerstone of national—and indeed global—economic revival (UNEP 2021a).

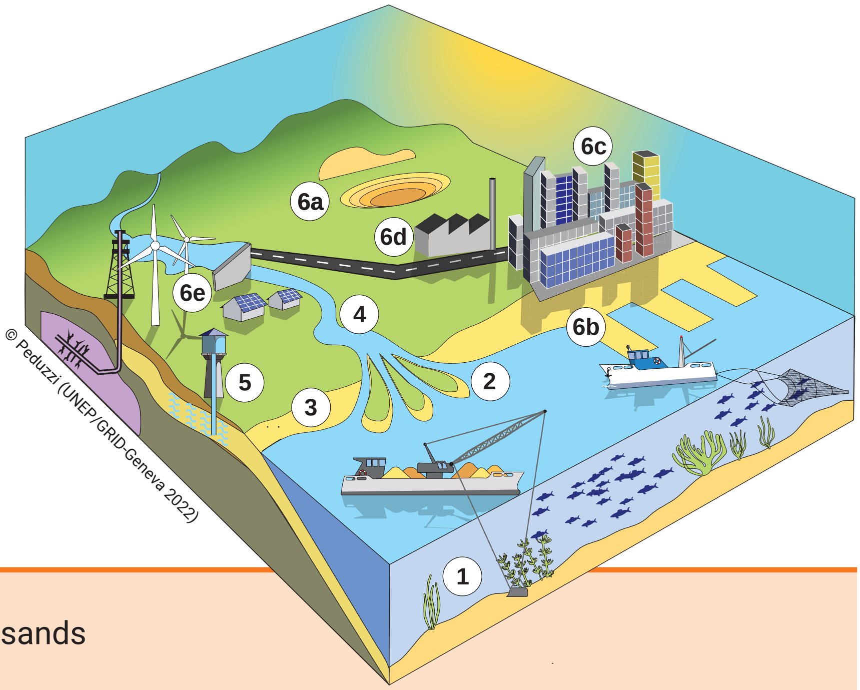
Sand also plays an important role in delivering ecosystem services upon which we are highly dependent and remain fundamental to achieving the SDGs (e.g., SDG 6, SDG 7, SDG 11, SDG 12, SDG 13, SDG 14 and SDG 15). For instance, across marine, delta, beach, river and underground environments, sand plays an important role in controlling erosion, delivering nutrients, contributing to food security, and regulating the quality of aquifers. By providing habitats and breeding grounds for diverse flora and fauna, sand also plays a vital function in supporting biodiversity (see Box 3).

Despite its irreplaceable value, societies are treating sand as an insignificant material. For one, there is no global inventory of sand production and use; as a result, reserves are incorrectly assumed to be infinite. Yet, long-term availability and supply of natural occurring sand and gravel should not be taken for granted, as short- and mid-term supply emerging as an issue in multiple places. In the regions where demand is not anticipated (i.e., in most, if not all countries), and planning and management policies are not implemented, sand and gravels are extracted from fragile spaces, e.g., beaches, agricultural land, zones of water supply, which in turn, giving rise to devastating ecological and social consequences and putting governments in challenging situations.

To meaningfully engage with the sand and sustainability challenge, there is a need to first recognise the strategic values of sand. This can be done by recognising the diverse forms, timescales, overlapping, and sometimes conflicting, functions of sand. As work is carried out to diversify building materials, generate stronger circular economies, and reduce the reliance on concrete and sand, both imminent building needs and the strategic work sand does in our environments must be considered. Questions of equity and distribution should remain at the centre of these considerations.

5 Four major categories of ecosystem services have been identified by the Millennium Ecosystem Assessment (Millennium Economic Assessment 2005): provisioning, regulating, cultural and supporting services. Refer to the glossary for further information.
6 It is estimated that 75% of infrastructure needed by 2050 - including health facilities, schools, dams for hydropower, housing - is yet to be built (Global Infrastructure Basel 2014).

**Figure 2 : Strategic value of sand in our natural and built environment**




## Box 3 : The strategic value of sands

### Ecosystem services

1. **Marine** : Sands are habitats for microorganisms and cyanobacteria as the basis of marine food webs (Peduzzi 2014), as well as benthic species. Sand dredging in marine environments leads to major impacts on fauna and flora (Desprez et al. 2010), with significant impacts on biodiversity and fisheries. Marine plants act as an important carbon sink, many of which require a sandy subsoil for their reproduction.
2. **Delta** : Deltas are areas of high biodiversity and high fertility, and thus vital for food security (SDG 2) - hosting and feeding millions of people. Deltas are already shrinking due to decreased sediment supply (e.g., caused by sediment retention in upstream dams, for example), land subsidence (due to groundwater extraction) and increased wave-tidal erosion. With shrinking deltas, these processes can impact the system even further inland.
3. **Beach** : Keeping sand on coasts may be the most cost-effective adaptation strategy. Beaches and dunes are important in protecting against coastal erosion where sand is an important barrier in the face sea level rise and increasingly frequent extreme weather events, such as storm surges (Apitz 2012), due to climate change; they also protect inland communities against storms. Coastal dunes provide habitats for diverse flora and fauna (Everard et al. 2010), support soil formation and nutrient cycling and offer protection against the salinization of coastal aquifers. Sandy beaches are also key sites of tourism- critical to many local and national economies.
4. **River** : Sand delivers nutrients to surrounding ecosystems, protects water sources, reduces riverbank erosion and controls river flows (regulation of floods and droughts) (Apitz 2012). In channel ecosystems, fish and invertebrates breed in riverbed and riverbank material, essential to sustaining healthy reproduction rates, which provide protein and food stocks for communities. Vegetation on sand bars has also been shown to aid processes of water filtration and denitrification (Gopal 2020).
5. **Subsurface** : Underground layers of sand and gravel are often aquifers that hold significant volumes of water, one of the main sources of potable water around the world.
6. **Infrastructures for development (including sustainable development) :**
   a. **Land use** : Static sand extracted from quarries and crushed rock has an impact on the landscape and may cause deforestation. Extraction is in competition with crop land, forest, built areas, water sources, protected areas, and leisure areas. However, impacts are lower compared to more dynamic environment.
   b. **Coastal use** : Sand protects shorelines (see above) and it is used for land reclamation, beach nourishment and to build harbour infrastructure.
   c. **Urban infrastructures** : Sand is used in the concrete to build roads, bridges, hospitals, industrial infrastructure, and housing.
   d. **Industrial use** : Sand is used in the production of glass and windows, while silica sand is used for electronic chips, rare earth, and aeronautics.
   e. **Energy** : Concrete is used to build hydropower dams and wind turbines. Silica sand is used to produce solar panels and in gas fracking.

## Key actions

### Action 1.1 : Understand, formalise, and evaluate the strategic value of sand

- Governments (cross-border, national, regional, and local) should participate in a thorough, rigorous inventory of the strategic values of sand (see Figure 2), and their alignment with the SDGs.
- Support the formal recognition of the value of sand (for both ecosystem services and infrastructure development).
- Implement economic policies to reflect the strategic value of sand in its pricing (e.g., by integrating externalities).
- Review options for taxes and subsidies to reveal different price points, consulting models that enable governments to better understand impacts on supply and demand.
- Understand how shifts in price may impact inequality. Consider possibilities for multiple markets for large scale, government and/or corporate pricing, compared to localised self-building projects for housing or small-scale commercial infrastructure.

A detailed inventory of the strategic values of sand should consider sand's overlapping functions across the environment, economy and society, highlighting the relationships between sand and its management in achieving the SDGs. It is imporant to evaluate the potential conflicts among these functions. The inventory should provide an estimate of the real costs of sand, if the externalities of extraction are included into the price, and compared with the value of the services provided by sand in the natural environment over time (e.g., coastal protection and contributions to biodiversity).

Steps should be taken to formalise the recognition of sand's strategic value by integrating sand challenges into existing governing domains and/or create new sub-departments where appropriate. Where new legislation is needed, legal action should be taken to formally recognise sand as a strategic material, with appropriate legal frameworks that ensure policies are developed and implemented, and compliance is monitored over time with clear accountability structures in place.

### Action 1.2. Anticipate increasing demand to enable planning

- Research and develop models to deliver insights into anticipated demand over time, including multiple demand scenarios, based on population growth, urbanisation trends, development of infrastructure, climate change impacts/adaptation and the uptake of alternative materials (Recommendation 8).
- Identify priority areas for restoration or infrastructure provision, taking into account potential impacts on equity.
- Establish a national map that is supplemented by sub-regional insights that can better identify the specific geography of demand and how supply might be managed in local sand economies, taking into account environmental and socio-economic outcomes (See Action 6.4).

The world's population will increase by an average of 1.9 billion inhabitants from 2020 to 2050 (UN 2021a ; UN 2021b). Africa will concentrate nearly 60% of the world population increase (+1 to 1.2 billion inhabitants) and Asia 33% (+400 to 900 million inhabitants) (ibid.). Population growth as well as the anticipated rural-to-urban migration will generate demand for new housing and infrastructure. In 2020, 56% of the world population was living in cities (4.4 billion people) (ibid.). In 2050, this figure will be 68.3%, increasing the urban population by 2.25 billion to reach 6.65 billion people. 89% of the world's urbanisation increase will be in Asia (50%) and in Africa (39%) (ibid.).

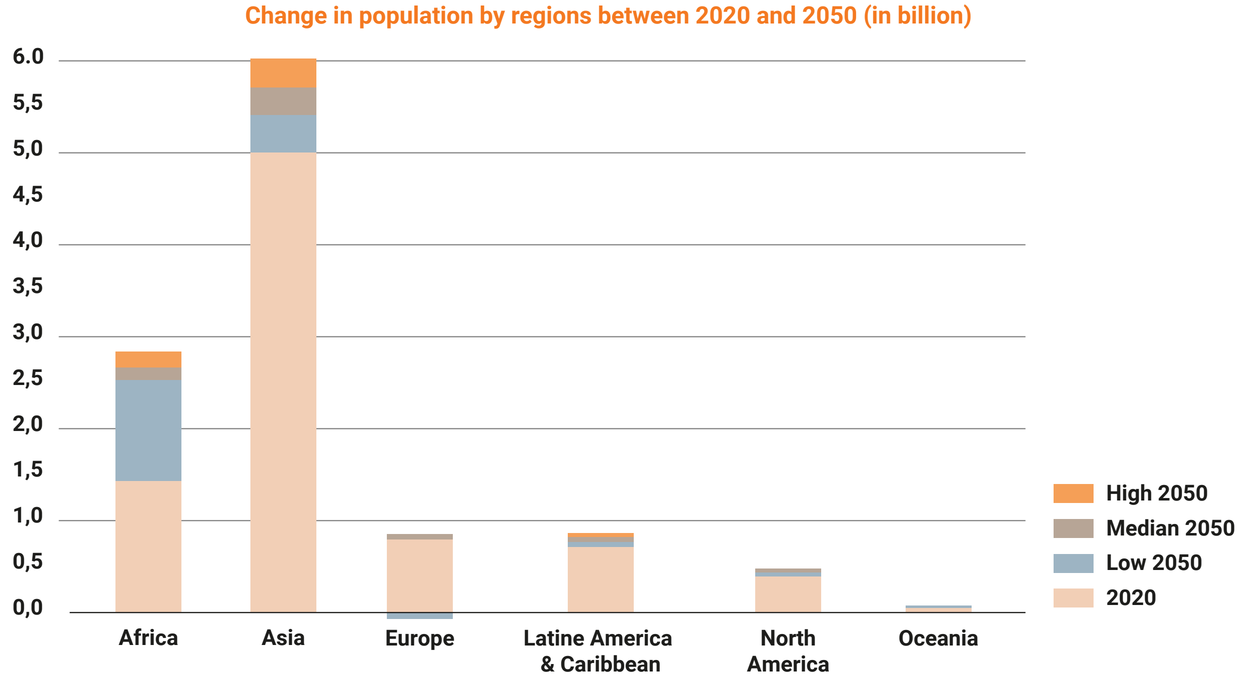
Urbanisation will increasingly take place in secondary cities, which will demand the extensive building of roads to connect these towns and cities to other urban hubs and surrounding areas, alongside initial investments in vital infrastructure such as drainage, sewage, and electricity. Existing infrastructure is also in need of upgrading[7] - particularly in places where building standards are harder to regulate and/or yet to be created (UNEP 2021a). With 50% of the building stock standing in 2060 yet to be built (ibid.)—much of which will be necessary to achieve SDGs 6, 8, 9, 10 and 11—anticipating increasing demand for sand becomes ever more urgent.

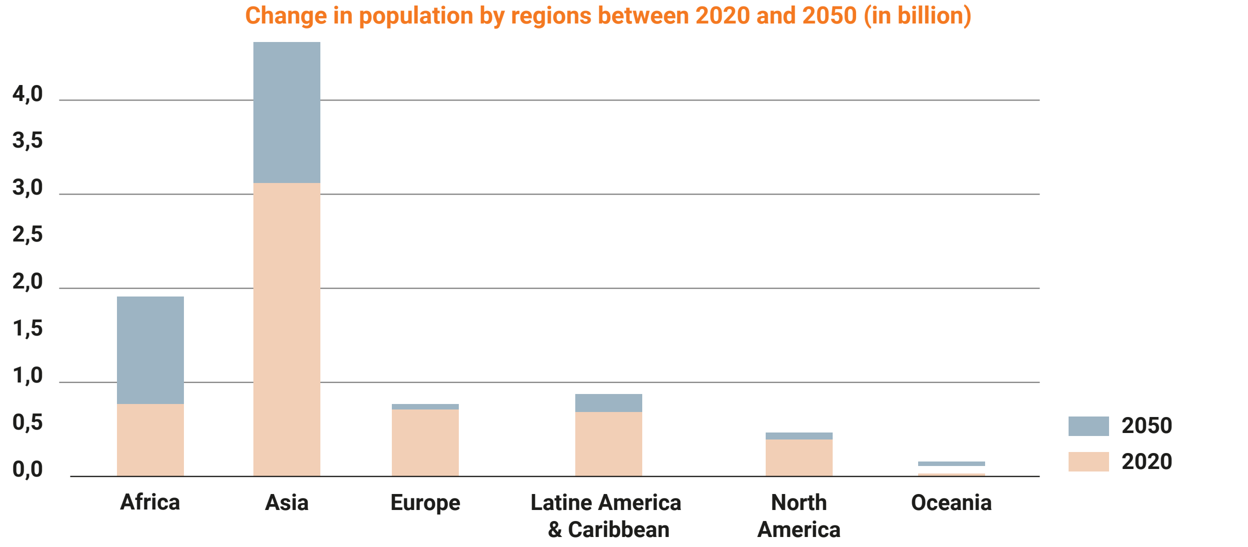
Anticipating the increasing demand should also take into account the impacts of climate change and adaptation needs. While significant strides are taken to implement nature-based solutions (NbS) against climate change challenges, it is important to note that NbS requires large volume of sand. Additionally, NbS may take time to have the desired effect. Thus in some cases, grey structures (i.e., concrete) may be necessary in the mean time to address challenges in the short- to medium-term. In the context of extreme heat and its impacts on cities, NbS

7 Depending on its quality, the lifespan of concrete is somewhere between 75-100 years, suggesting that a significant portion of the global concrete currently in structures will need to be replaced or significantly upgraded in the near future.

will also be instrumental to promote building designs and materials that require neither concrete infrastructure nor sand (UNEP 2021b). Climate change induced pressures, such as temperature stress and precipitation, will also speed up the degradation of existing infrastructure and the need for upgrading or replacement.

**Figure 3 : Projected population increase and urban population trends between 2021- 2050 (with low, median, and high scenarios)**




Data sources : (UN 2021a ; UN 2021b).

### Action 1.3. Consider the strategic role of sand with respect to climate change and biodiversity loss

- Consider the direct and indirect contributions of sand extraction to climate change.
- Estimate the value of sand as an asset that protects against the impacts of climate change.
- Evaluate the function of sand in maintaining biodiversity (see Box 3).

Steps should be taken to better understand the direct and indirect contributions of sand extraction to climate change and other environmental crises, including climate change and biodiversity loss. The relationship between sand and climate change is significant and complex. For instance, the extraction of marine sand releases GHG trapped in sediments (direct) (Sala et al. 2021) and the process of producing concrete releases $CO^2$ (indirect). In the natural environment, sand also functions as an important asset that mitigates the impacts of climate change, including protecting against coastal erosion, storm surges, coastal flooding and salinisation of coastal aquifers. This is particularly important given the accelerating rise of Global Mean Sea Level (GMSL). Under various scenarios, GMSL will increase between 0.37 and 1.88 m by 2100, affecting land that currently hosts between 147 and 216 million people (IPCC 2021). 70% of the world's beaches are also eroding due to a rise in GMSL, increasing wave intensity and reduction of sediment reaching the coast (Oppenheimer 2019). Additionally, more than 20% of the world population and half of the world's fastest-growing megacities live on low-lying sedimentary coasts, many of which are sinking at an even faster pace due to land subsidence - a process known as *relative sea level rise* (ibid. ; IPCC 2019). In some locations, if sand were not extracted from rivers and coasts, large areas of new land could be gained over the sea, or coastal areas would continue to gain elevation over rising seas in a natural manner and without any human action required. Keeping sand on coasts may therefore be the most cost-effective adaptation strategy.

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# Recommendation 2 : Include place-based perspectives for just sand transitions



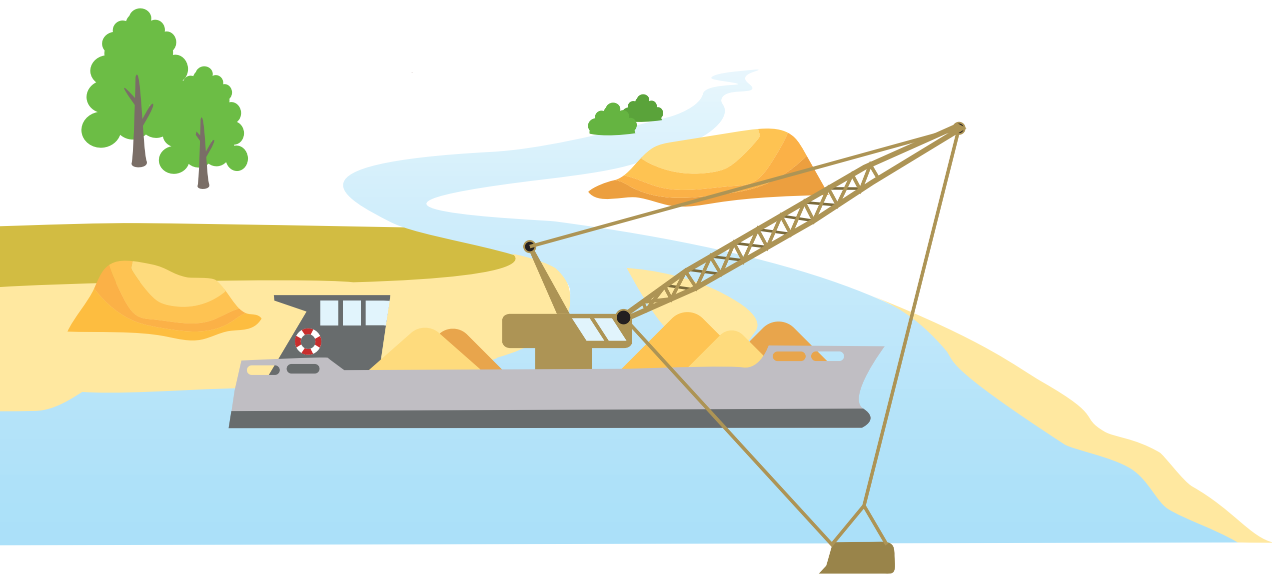
## Summary

Sand, whether extracted from the natural environment, or manufactured from the crushing of stone, is a material intimately linked with place. Every location from where sand is extracted has a unique environmental, social, political, and economic setting that shapes its sustainability. Effectively addressing the environmental implications of sand extraction will require the consideration of social, political, and economic dynamics. This includes the participation and inclusion of all interested and affected people in sand resource governance and decision-making, and a just transition for the sand workforce impacted by sector reform.


Sand, like other development minerals, is overwhelmingly a locally consumed resource (Franks 2020). Dictated by the economics of transportation, locally extracted sand typically services local markets. With the exception of marine sand, which requires expensive vessels, sand is principally extracted by large numbers of small- and medium-sized domestic enterprises who rely on sand for their livelihoods and, in the developing world, are often in circumstances of poverty. The sustainability of sand is therefore critical to poverty reduction (SDG 1) and decent work (SDG 8) (Bendixen et al. 2021). Sand is strongly linked to both the livelihoods of those that harvest or mine sand, and to those that rely on the ecosystem services that sand provides within natural waterways. Equity (SDG 10), peace and justice (SDG 16), participation and partnership (SDG 17) must underpin all of the other recommendations on sand sustainability if we are to achieve a sustainable transformation of the sector.

## Rationale

The immense scale of global sand extraction, and the historical neglect of this sector, makes this issue an important —and challenging—one for global sustainability. Millions of people mine sand in thousands of places, with impacts accumulating at local, regional, national, continental, and global scales. A huge transformation is necessary, one that will affect very large numbers of people. It is critical, therefore, that as a global community we bring people along on the journey toward sustainable development so that such transformation is inclusive and just for all parties[8].



8 The Mosi-Oa-Tunya Declaration on Artisanal and Small-Scale Mining, Quarrying and Development provides some guidance on the issues facing the formalisation and transformation of the informal mining sector. See Franks et al. (2020).

## Key actions

### Action 2.1 : Include the voices of all people potentially impacted by policy, action, and advocacy for sand sustainability

- Involve all relevant actors in decision-making, and the design and implementation of any programs or policies at all scales.
- Ensure that language is inclusive and does not overly generalise or stigmatise groups in the sand supply chain who are necessary to mobilise for change.
- Provide accessible pathways for the formalisation of sand mining accompanied by well-designed environmental and social obligations.

Any transformation in sand governance must recognise the diversity of settings in which sand is extracted and be guided by those voices most closely involved and influenced by sand extraction, whether it be the miners who may rely on sand for their livelihoods, the businesses and consumers who receive the benefit of sand's utility, or the local communities who are dependent on the presence of sand in ecosystems for healthy waterways, clean drinking water, and the protection of their livelihoods (Recommendation 1). Involving all actors is essential for mobilising a successful coalition (see Table 4). Participatory approaches, that are also based on the protection and respect for human rights, are necessary at all scales, including at national and global levels where decisions are often dominated by expert viewpoints. This is especially the case for excluded and marginalised groups, such as ethnic minorities, the poor, women and for those whose involvement in the sector might not be obvious at first, but who may bear the brunt of the impacts of sand mining or transitions away from sand mining.

Inclusivity is also important in the language that we use. In too much of the written literature and media on sand and sustainability, the only reference to the large number of – often informal – sand and aggregate miners in developing countries is as criminals, using pejorative and stigmatising terms such as 'illegal sand mining' and 'sand mafia.' In reality, sand mining is a livelihood diversification activity for large numbers of people in poverty. There are significant barriers to artisanal and small-scale miners to obtain legal licences, and in some countries, sand is excluded from the formal definition of 'minerals' in the mining act, leaving no opportunity to mine 'legally.' Loose application of the term 'sand mafia' implies that informal sand miners are in positions of power, which is counter to the actual situation in many settings. This is not to say that sand mining actors will welcome change. There are actors and businesses within the sand supply chain that are not motivated by livelihood concerns, and instead operate to maximise economic benefit. There are also circumstances where miners, informal and formal, large, and small-scale, have extracted without concern for the environmental and social consequences, have resisted calls for change, or have used power, corruption and even violence, to entrench the status quo. However, the generalisation of examples where sand mining is linked with criminal activities or criminal networks to represent the global situation is counterproductive to the desired sustainable development outcome and reverts to an earlier time where the analysis of environmental issues was divorced from the human development implications.

While formal sand mining does not necessarily equate to sustainable sand mining, formalisation can nevertheless be one pathway toward a more responsible, well-governed and sustainable sector, if it is context specific and designed to balance the legitimate interests of all parties.

### Action 2.2 : Accompany any change toward sustainable production with a just transition, and avoid any deterioration in workers' rights, increased hardship, or poverty

- A just transition is necessary to ensure any people impacted by sectoral change are provided with the necessary support to maintain and improve livelihoods.
- Finance and capacity building should accompany sectoral transformation for a just transition and can help to mobilise support for change, which include opportunities for women and other excluded or marginalised groups to directly benefit from these solutions.
- Justice is also important from an intergenerational perspective, the integrity of the dynamic ecosystems most impacted by sand extraction is critical not only for current generations but also those of the future.

Sustainability transformations require fundamental changes to production systems. They also require careful attention to the social dimensions. A just transition refers to a range of social interventions necessary to ensure workers' rights and livelihoods are at the forefront when economies are shifting toward sustainable production. This concept has been utilised most prominently in climate change debates; however, it is equally relevant to the transformations necessary in sand sustainability. Ensuring a just transition is important from both an ethical perspective, due to the disempowered position of many involved in the sector, and from an effectiveness perspective, as mobilising large numbers of people in practice change - many of whom are in circumstances of poverty - will only be possible if that change results in an improvement in livelihoods.

## Box 4 : Case study – Water security and sand extraction in Sri Lanka

A women's volunteer organisation, NetWwater (Network of Women Water Professionals) was founded in 1999 to promote gender mainstreaming and holistic water management in the water sector in Sri Lanka. In 2005, it started a Gender and Water Dialogue in the North Western Province when women reported the drying up of dug wells, which are an important source of domestic water. This was due to declining water levels in the vicinity of excessively mined rivers. The 2004 tsunami precipitated a construction boom, at which point sand demand was estimated to be 8 million cubic meters ($m^3$) /annum, and has risen steadily to 70 million $m^3$/annum today (GWP 2018). Despite a Supreme Court intervention in Deduru Oya, which allowed mining only at specific locations, mining outside of these legally demarcated areas continued.

Women, who previously had easily available access to drinking water, were now forced to travel 3 to 4 km in search of water due to the impacts of river sand mining (RSM). In the early days of activism in Deduru Oya, women took on an active role in demonstrating and acting as human shields to the activists at the river banks. After studying the extent of the negative impacts of sand mining in Deduru Oya, NetWwater activists, with the support of the Sri Lanka Water Partnership (SLWP), catalysed the formation of a local awareness and advocacy network, the Deduru Oya Protection Campaign. Recognising weak law enforcement mechanisms and legal loopholes meant that regulations alone were not enough to fully address the impacts of RSM, NetWwater and SLWP supplemented legislative changes with community action. Awareness campaigns and dialougues were conducted with different stakeholders, such as government officials at the district and divisional level, local authorities, media, youth and NGOs, emphasising on transparency and accountability.

They raised awareness at the national level and supported the development of the 2006 National Policy on Sand as a Resource for the Construction Industry, which was initiated to manage the construction sector in a sustainable manner. SLWP understood that in order to truly move away from river sand mining, viable alternatives to sand would need to be identified and taken on. They partnered with the construction industry regulator, the Construction Industry Development Authority (CIDA), to organise a series of consultative and awareness-raising workshops and brainstorming sessions under CIDA's programme, Alternatives for River Sand in Construction.

Although RSM in Sri Lanka is now either entirely prohibited in sensitive areas or highly regulated according to strict extraction and transportation schedules, some regions in Sri Lanka are still facing challenges of illegal sand mining carried out by politically influential persons. While more stringent RSM regulation has led to an increased interest in alternatives to river sand, expanded advocacy programs are still needed to ensure water security in Sri Lanka.

*Source :* Kusum Athukorala

Just transitions are important for all impacted workforces, employed by small, medium, and large-scale enterprises, however, they are especially important when the workforce operates in circumstances of poverty (or is at risk of impoverishment). Any effort to ban or limit mining from certain environmentally sensitive locations should be accompanied by:

- opportunities to access alternative sand resources (e.g., static rather than dynamic sources of sand such as terrestrial deposits and quarries);
- support and access to alternative livelihoods for those miners that are open to working in a different field;
- access to finance and a policy environment that facilitates the transformation from informal, low technology operations to more formal, productive and secure mining and quarrying, and;
- capacity building support to acquire the skills necessary to adopt sustainable business practices.

Consistent with Action 2.1, the design and implementation of such a transition should be undertaken in a participatory, inclusive, and transparent manner. The introduction of policies to limit mining may constitute a form of involuntary resettlement and should thus be carefully planned, including the preparation and implementation of resettlement action plans. Getting a just transition right requires sophistication and significant resources and in practice often falls short of intentions, which raises the stakes for such decisions.

Lack of access to affordable and tailored financial products; skills, training, and technology; affordable and accessible mineral licensing; and alternative sand resources is often cited by miners as key barriers to reforming practices. Where the transformations necessary require new skills, techniques and production patterns, capacity building can be an effective means of mobilising support for change.

A just transition is also an important consideration from an intergenerational perspective. Sand plays a critical role in existing ecosystems (Figure 2). The functionality of these ecosystems is not only important for current generations who rely on them for ecosystem services, but so to those of the future.

### Action 2.3 : Governance should be at the same scale as the issue (subsidiarity)

- Solutions should be scaled so that decisions are retained by the lowest possible level of governing body consistent with their resolution.
- Decision-making undertaken at the right scale, will result in more relevant solutions with a greater chance of success.
- Accountability and transparency are important aspects of effective governance at all levels.

The impacts and implications of sand extraction play out at a range of scales. Solutions therefore must also be scaled. Sand governance must be strategic and follow the principle that decisions are retained by the lowest possible level of governing body consistent with their resolution. This principle is sometimes known as subsidiarity or political scaling. For scaling to be accomplished the devolvement of power by government is often necessary (see Figure 4). Solutions also must be relevant to the place in which they are implemented. Solutions that work in developed economies where the sand sector is predominantly formal, may not be successful in emerging economies where informal markets are the norm. Ensuring that decision-making is undertaken at the right scale, will result in more relevant solutions with the most chance of success.

**Figure 4 : Examples of scaled sand governance**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**Level 1** : Local – community elders may decide that a stretch of river is important for irrigation of local land in the dry season due to the sand working as a water trap and forbid harvesting or mining in that area.

**Level 2** : District – a district authority may restrict the number of trucks transporting sand to a city and due to low sand replenishment rates requires sand extraction only to be carried out (and sand to only be used for construction) in its own district.

**Level 3** : Regional – regional authorities implementing a large infrastructure program may notice the interconnected naturally occurring sand supply and instigate a big picture plan.

**Level 4** : National – the development of the nation is based on the use of sand for concrete and so some goals/aims from lower levels of scale accommodate a new national (level 4) policy or law on sand sector formalisation.

**Level 5** : International – capacity building and cross-boarder monitoring may result from global cooperation and coordination.

# Recommendation 3 : Enable a paradigm shift to a regenerative and circular future

## Summary

Since the industrial revolution, sand has become an important commodity used to build and sustain our economies. However, the hitherto invisible trade-offs made in the process of such commoditisation are becoming increasingly concerning and unacceptable. Recognising key drivers that underpin our economies, addressing barriers to scaling up regenerative solutions, and embracing diverse materials, methods and models are vital to enable a circular future.

## Rationale

Sand supply is often perceived to be unlimited. However, since naturally occurring sand can be finite and non-renewable in timescales relevant for policy makers (Van Lancker et al. 2019), its uses and their inherent trade-offs need to be examined closely and re-evaluated. Often, the physical and socio-economic scarcity, competing uses or the cumulative impact of extraction (Pereira 2020) are not taken into consideration (Recommendation 1). Our current systems also do not consider the immense cultural, spiritual, and religious importance of sand in many places nor the effect of losing such heritage. The triple planetary crises of the climate emergency, the ongoing critical loss of biodiversity and the toxic trail of pollution and waste makes it imperative for us to change how we operate. Experience has shown that it is possible to meet the needs of the present without damaging the ability of future generations to meet their own needs, using regenerative and circular materials and processes (Recommendation 8). However, in order to scale-up these solutions quickly, a paradigm shift in current organisational and economic structures is required.

## Key actions

### Action 3.1 : Break silos to accelerate innovative approaches through public-private knowledge networks

- Establish a baseline map of all sand-dependent industries and potential markets within each country. This will shed light on material flows, potential points of leverage as well as areas requiring strategic research.
- Establish public-private knowledge networks with national governments, extraction industry, start-ups, universities, research institutes and civil society supporting the exchange of expertise. Cross-sectoral and cross-regional cooperation will help accelerate innovation and co-design best practices.
- Boost consumer confidence in the regenerated resource through certifications and public procurement.

Sand supply chains contain a multitude of actors from both the public and private sector (Recommendation 9). However, they often work within silos. Stakeholders often collaborate only within their own domain or market, limiting the innovation which can stem from cross-sectoral exchange. In addition, innovation can be impeded by regulation that is yet to catch up and the voices of civil society actors can get lost.

Public-private knowledge networks consisting of national governments, the extraction industry, academics, knowledge institutes and civil society could close the gaps between policy and implementation. This would accelerate the dissemination and implementation of practical and sustainable solutions by approaching the sand supply chain and ecosystem as a whole.

In a pilot project in Spain for example, spent foundry sand was reclaimed and used in construction applications (Box 5). Such pilot projects are required to prove solutions' technical and economic feasibility, and thereby break the silos that currently exist in policy between industrial and construction sand use (Pereira 2020). The benefits are manifold. Developing a symbiosis among currently siloed industries and sectors can not only enhance the long-term viability of sand-dependent industries, provide additional resources, save landfill space for municipalities, but also safeguard ecosystem services provided by sand for future generations, minimise biodiversity loss and address the climate emergency.

### Action 3.2 : Align fiscal policy with a regenerative and circular future

- Identify and address potential barriers and misaligned policy incentives.
- Provide clear guidance/market direction in favour of regenerative resources rather than non-renewable ones to help them scale up fast.

Fiscal policy has a profound influence in both mature and emerging economies. Potential barriers need to be identified and addressed to reduce consumption and help regenerative solutions scale up fast (Box 6, as well as Action 3.4).

## Box 5 : Case Study - LIFE ECO-SANDFILL Project, Spain

### Background

The LIFE ECO-SANDFILL project aimed to demonstrate the technical and economic feasibility of using reclaimed Spent Foundry Sand (SFS) as a fine aggregate in construction applications (European Commission n.d.). It was co-financed by the LIFE Program, the financial instrument for the Environment and Climate Action of the EU. There are around 3,000 active foundry operations in Europe that generate over 6 million tons of waste sand annually (Delgado et al. 2016). As the project description says "Only 25% of this SFS is recycled for a few applications, mainly by the cement industry, but these sectors are unable to absorb the total amount of sand generated, so the remaining 75% is landfilled. However, re-using SFS can help minimise the environmental impacts from sand extraction, processing, and transport.

The global warming potential of sand extraction (from quarrying and dredging) and processing is between 92-120 g $CO^2$ eq. per 1 kg of dry silica sand obtained. Air pollutants are emitted by the extracting equipment (usually diesel), and noise is a common occurrence due to extraction and transportation. Sand extraction involves considerable land take and loss of soil (estimated at 0.4 ha per ton of sand extracted), with associated loss of wildlife habitat. The re-use of SFS would minimise these impacts."

**Screed mortar for indoor use**

© LIFE ECO-SANDFILL

### Implementation process and stakeholders

The consortium involved five partners from Spain and the project ran for 36 months. Three full-scale case studies were implemented in the construction works for a High-Speed Train in Spain.

### Replicability

The LIFE ECO-SANDFILL project's objective of reusing a waste stream to divert it from landfill was aligned with the EU's Roadmap to a Resource Efficient Europe (European Commission n.d.) and the 7th Environment Action Program (European Commission n.d.). The technique was found to be suitable for all types of sand and moulding systems. It has high replicability potential, provided that toxicity and leaching concerns are addressed either through hydraulically bound construction applications or special conditioning treatment for unbound applications (Garitaonandia et al. 2018).

Beyond the project's alignment with existing policy frameworks, it also benefited the local economic context. Participating foundries saved up to 75% in sand waste management costs per ton of SFS diverted from landfill and reclaimed for reuse. There was also a substantial decrease of over 80% in raw material costs (excluding transport costs) from the sand purchases avoided at the foundry as well as the replacement of silica sand with SFS in mortar screed (LIFE ECO-SANDFILL n.d.).

### Action 3.3 : Encourage capacity building within key sectors

- Offer local governments training opportunities on mineral resource governance. Such training should include the potential end-uses and the long-term environmental and social impact of mining, especially through a gendered lens in keeping with SDG 5.
- To ensure a just and inclusive transition (Recommendation 2), develop alternate livelihood programs for miners and specific programs to boost resilience of mining-impacted communities. Improved diversity and inclusion can support the resilience of society and contribute to SDG 11.
- Realign professional education towards a regenerative and circular economy.

Capacity building at all levels is fundamental to a just transition. Experience has shown that gender-based approaches empowering women in particular can benefit entire communities (ibid.). In addition, professional education within key sectors needs revisiting.

The current system of professional education is not geared towards a regenerative and circular economy. This is a significant barrier as many professionals are trained on outmoded models of development. In the UK, 77% of respondents who participated in the Architects' Climate Action Network Student Survey felt their course was not adequately preparing them to address the twin crises of climate and ecological breakdown. Respondents believed that "aesthetics are valued more than sustainable design" (Students Climate Action Network 2021). Facilitating urgent reforms of the curriculum in key sectors including Architecture, Engineering, Mining, Finance can speed up such capacity building.

**Figure 5 : Students' response in a survey by Architects' Climate Action Network**

**Do you feel your course is properly preparing you for your future work ?**


© Adapted from (Students Climate Action Network 2021)

### Action 3.4 : Create incentives for public and private investment in sustainable activities related to sand

- Facilitate shifts in financial streams to drive durable change.
- Identify sustainable practices for sand, either in extraction, application or in deploying alternatives, to incentivise funds for structural and sustainable change in the sand supply chains.

A transnational framework categorising sustainable activities can help both the private and public sector to divert investments towards environmentally friendly activities, which are investigated and approved by national experts of the participating countries. The framework can then be (voluntarily) applied to tax benefits for investments or criteria for the award of funds, loans or in procurement.

Knowledge networks can evaluate a list of activities related to sand sectors which are considered a sustainable investment. As a result, financial streams can be shifted away from sand related sectors with poor socio-environmental records. A sustainable finance categorisation can be applied in government fund allocation for instance and serves as an incentive for the private sector to invest in sustainable projects. This can help build or restore reputation and recognition of a sustainable activity. An example of how such a voluntary framework can have far reaching impacts is the development of the EU Sustainable Taxonomy (European Commission n.d.), listing all activities the EU deems sustainable (see also Action 10.4).

### Action 3.5 : Leverage insurance in favour of regenerative practices and materials

- Based on the EIA, infrastructure contractors should take ecosystem insurance covering damage done to the natural environment. Such ecosystem insurance should work in-hand with restoration and compensation measures (Recommendation 10).
- Remove regulatory and insurance barriers for regenerative materials.

Large scale infrastructure projects and sand extraction can change and/or damage biodiversity in marine, coastal or terrestrial environments, with repercussions for economic livelihoods. Numerous companies already undertake EIAs at the start of an extraction project, to insure against incidents causing immediate harm to the environment or local communities. However, unexpected consequences do arise over time (e.g., workers in the fisheries sector losing livelihoods and ecosystem disruptions due to mining of riverine sand.) For large-scale infrastructure projects, standards and specifications for design, construction and operation of infrastructure should be in place to ensure against unexpected ecosystem damage.

One promising example integrating ecosystem damage insurance into construction procurement projects is the Standard for Sustainable and Resilient Infrastructure (Global Infrastructure Basel 2021). This sustainable infrastructure certification scheme can help input sustainability into the project tendering through its specifications set on pollution and resource management, biodiversity, climate protection and resilience, as well as land use criteria. This can drive projects to reduce negative impacts (e.g., by employing recycled materials instead of new concrete), and create positive impacts (e.g., by regenerating habitats through NbS replacing 'grey engineering' (Box 12). Additionally, regenerative projects, which restore or enhance ecological value and are considered innovators, can be recognised. In some cases, a lack of regulation on embodied carbon[9] in building regulations (European Environmental Bureau 2021 ; Architects Climate Action Network 2021) and the undersupply of insurance for regenerative materials are significant barriers (Timber Accelerator Hub 2021) that need to be addressed. Enabling a regenerative and circular future is fundamental to the responsible governance of sand resources. It requires identifying and eliminating barriers, promoting cross-sector collaboration, and aligning disparate pieces of the current economic system.

### Action 3.6 : Embrace diversity of building materials, methods, and business models

- Densely built, low-rise buildings are the future – not skyscrapers (Pomponi and Saint 2021).
- Tap into the wide variety of alternate building materials and methods available.
- Re-establish pride in vernacular architecture.
- Facilitate the creation of digital and physical infrastructure (e.g., warehouses) required to rework and store building materials reclaimed from urban mining.

"The built environment is the greatest cause of carbon emissions, global energy demand, resource consumption and waste generation" (Pomponi et al. 2021). In 2020, human-made mass was found to outweigh all living things (Elhacham et al. 2020). As humanity thinks about the legacy we wish to leave behind in the Anthropocene, learning from the past can shed light on biases that are embedded within systems and mindsets. Before colonial powers imposed their building codes in their colonies, architecture was a vibrant expression of each place and its people. Re-establishing pride in vernacular architecture can be a win-win solution. Tapping into local culture and vernacular traditions can provide important place-based perspectives (Intbau 2021) (Recommendation 2) and solutions to the sand and sustainability crisis.

Densely built, low-rise environments have been found to be more space and carbon efficient, while high-rise buildings have a drastically higher carbon and material impact (Pomponi and Saint 2021). Depending on the geography, the skills available and the building regulations, there are a wide variety of alternatives to create such a built environment. Modern methods and forms of construction are driving innovation in the natural building sector. Prefabricated panels and modular designs can greatly reduce build times and cost. Some prominent alternate methods are timber construction including engineered wood such as cross-laminated timber, glued laminated wood (Glulam), bamboo construction, straw bale construction including prefabricated industrial panels, rammed earth, cob, adobe, compressed or stabilised earth blocks and other types of earth construction, and biophilic construction elements such as mycelium insulation panels.

There is also an urgent need to "mine the Anthropocene", using and reusing existing materials/products instead of continuing to mine primary materials (Miller 2021). Urban mining can provide both materials and opportunities for job creation within urban centres, apart from the climate benefits. There are many promising examples of such reuse (see Baker-Brown 2017). Creating buildings that can be deconstructed and reassembled, alternative business models such as offering products as services instead are some other ways, we can embed circularity into the built environment.

Several publicly funded research projects are working on articulating the benefits of natural building methods, improving results, and designing ways of bringing in circularity into the built environment. Examples of some EU-funded projects are UP STRAW, COBBAUGE, FCRBE, BAMB, CIRCuIT (Interreg n.d. ; BAMB 2020 ; CIRCuIT n.d.). The more diversity we can build into the palette of building materials, methods, and business models, the greater will be the resilience of societies.

9 $CO^{2}$ emissions associated with materials and construction processes throughout the whole lifecycle of a building and includes $CO^{2}$ emitted during the manufacturing of building materials, their transport for distribution and job site, and construction activities (UNEP 2021a).

## Box 6 : Case Study - The profound influence of fiscal policy in both mature and emerging economies (UK and India)

### Background

Fiscal policy plays a crucial role in aligning actions with the intended goal in both mature and emerging economies. Misaligned policies can lock in the status quo or worse, end up incentivising unhelpful behaviours

**UK** : Architects' Journal, the UK's best-selling weekly architecture magazine and the voice of architecture in Britain has been leading the 'RetroFirst' campaign calling on policy makers to prioritise retrofit over demolition and rebuild (Hurst 2019).

The Architects' Journal points out that of the 200 million tons of waste generated in Britain annually, 63% is construction debris. More than 50,000 buildings are lost through demolition every year and, although more than 90% of the resulting waste material is recovered (MPA 2019) much of this is recycled (MPA 2020) into a less valuable product or material, rather than being reused.

Maintaining existing buildings and retrofitting them attracts a higher Value-Added Tax (VAT) rate of 20%. Current practices (early 2022) make it cheaper to demolish and rebuild, since the VAT rate ranges only from 0-5%. Such a distorted VAT policy is incompatible with tackling the climate crisis, the biodiversity crisis, and reducing demand for sand. Instead, such a fiscal policy incentivises demolition and financially penalises retrofitting efforts.

**India** : 'Stubble burning', the annual process of burning of crop residues across farms in the Indo-Gangetic plains is highly contentious and a major contributor to regional air pollution (Abdurrahman et al. 2020). Yet farmers are either unaware of alternatives or cannot afford to dispose of crop residues in an alternate manner. Research on how to convert such waste crop residue into building material is therefore highly relevant.

Building materials manufactured by repurposing and upcycling waste streams in India attract a Goods and Services Tax (GST) rate from 5 % to 12%. In comparison, materials for concrete construction such as concrete blocks and cement attract a GST of 18 to 28% (India, Ministry of Finance 2021). Two high-potential start-ups have benefited from this policy incentive, with their founders recognised on the 'Forbes 30 under 30 - Asia' Lists in 2019 and 2021 respectively.

- GreenJams produces Agrocrete®, a building material made of crop residues and a proprietary binder made from industrial by-products (Greenjams n.d.). The product is carbon negative and offers a cheaper construction cost. Raw materials are tested through regular X-ray Fluorescence analyses to check for heavy metal oxides and other toxic substances. GreenJams has received various grants from state and central government schemes such as Punjab Agri Business Incubator and Nidhi Prayas. The company has also attracted private equity funding. Their goal is to scale-up to cover 1 billion sq. ft of built area using Agrocrete® within 5 years.
- Strawcture Eco produces AgriBioPanels™, made of more than 90% straw and a proprietary binding adhesive (Strawture Eco 2021). The panels are suitable for a wide variety of applications, mitigate natural resource depletion, prevent air pollution, while building a value chain supporting farmers' livelihoods. The products are ISI-certified, fire resistant, moisture resistant, termite proof, formaldehyde-free, UV resistant, carbon negative and offer great acoustic insulation. E.g., The acoustic panels were used to build the library and multi-purpose hall at the Heritage International School, Gurugram in India. The panels have also been used in prominent Indian hospitals including Jayadeva Hospital, Bengaluru. Rapid construction can reduce costs tremendously as was the case for Vistex Hospital, a 6,000 square feet facility built in under 80 days in Patna, Bihar. The company is working on extending its manufacturing base across India to ramp-up and streamline production.

### Replicability

It should be noted that although Portland cement attracts a 28% GST, river sand and other naturally occurring sand still attract only a 5% GST, despite the immense destruction caused by the scale and pace of river sand mining. Such a policy is weighted in favour of business-as-usual. In enabling a paradigm shift to scale up regenerative, bio-based alternatives, added incentives providing clear market direction are highly welcomed.

In general, in mature economies with a built infrastructure, it is essential to prioritise reuse rather than new build. In emerging economies, where infrastructure is still being built up, tax incentives to upcycle materials is a step towards sustainable sand supplies. As these examples demonstrate, there is tremendous potential in managing our material flows and upcycling current waste streams to reduce the demand for sand and eliminate it altogether, where feasible and cost-efficient

Jayadeva Hospital, Bengaluru, India

© Strawcture Eco

© GreenJams

## Two high-potential start-ups have benefited from an Indian policy incentive

In general, in mature economies with a built infrastructure, it is essential to prioritise reuse rather than new build.

In emerging economies, where infrastructure is still being built up, tax incentives to upcycle materials is a step towards sustainable sand supplies.

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AgriBioPanelsTM

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# Recommendation 4 : Integrate policy and legal frameworks strategically


## Summary

Strategic and integrated policy and legal frameworks should support responsible sand sourcing and management, including promoting alternatives. National and subnational policy and law play essential roles in shaping behaviour and outcomes across different stakeholders in the production and consumption of sand resources, and their alternatives. These institutions function to balance different needs, set sustainable and equitable goals, and shape legal, international, political, market, and social dynamics to pursue these. Coherence in purpose, related line ministry functions, implementation and intended outcomes across sectors and stakeholders is key to finding this balance.

To succeed, they must be in tune with local, national, and regional realities while responding directly to the need for accelerated transitions to a wiser stewardship and use of sand resources. The drivers of sand over extraction and consumption are thorny. Resources to address these are often limited, thus there's a need to do more with less and find strategic leverage points, with the goal of avoiding or reducing competition across multiple and many worthy objectives.


## Rationale

Clear calls have come for an evolution in policy and legal institutions shaping sand extraction practices and major uses because current approaches often cannot regulate these shared resources in strategic, coherent, and equitable ways (UNEP 2019).

Sand extraction falls between the gaps between mineral, environment, water, marine and land use policy, and legislative frameworks in many countries. Mineral resource regulatory regimes are the focus of much sand policy discussions even though sand material flows are inadequately addressed in this domain. High-consumption volume sand is conceived to be a low-value development mineral and of a lower priority compared to high-value export minerals. Moreover, some of the most problematic extraction is that which occurs in dynamic environments like rivers, lakes and coasts governed by areas of policy and law like environmental legal regimes, water resources policy and management, coastal zone management, infrastructure, urban and land use planning, fisheries management, and biodiversity policy, which often do not address sand extraction governance and management adequately, if at all. Concession and permitting systems can be highly complex and difficult to comply with (Recommendation 5); and monitoring (Recommendation 6) and enforcement difficult to implement and under-resourced.

A key assumption underpinning Recommendation 4 is that integrating policy and supporting legal frameworks,

- **horizontally**, across national ministry objectives and their separate strategy and implementation mechanisms to create cross-sectoral goals and approaches;
- **vertically**, through jurisdictional levels of global, regional/transboundary, sectoral, national, and subnational policy and law; and,
- **intersectionally**, with the recognition of interdependence and complex patterns of interaction that link intended and unintended effects of policy and legal action and inaction

will encourage policymakers and other actors to examine established practices, consider different needs to be met and ask how diverse populations are affected. These considerations will help guide transitions towards sustainability through policy and legal interventions that advance societies in positive directions, are implementable and just (Lafferty et al. 2003 ; Briassoulis 2017).

An approach like this to integration across policy domains[10] can help when uncertainty is high, different values are in play, consensus on problems and interventions is low, and collaboration, co-decision and joint action is needed to make progress (Hoppe 2018). Combining assessment processes in mineral, environmental and land use regimes, for instance, could inform a more ordered resource exploitation while protecting local needs. It can support strategic anticipation of materials demand and allocation of resources across a full range of needs in society (Recommendation 1); in the case of sand and its alternatives, that means securing necessary construction and industry resource inputs while ensuring co-

10 Policy domains are also referred to as "Policy areas", "policy sectors", "subsystems", "dimensions", "programs.

benefits of keeping sand flowing through ecological systems are not lost (Recommendation 10). Joined up approaches also help identify the worst impacts of sand extraction and regulate, incentivise, and coordinate the actions needed by many different players to mitigate them. They can change incentives and barriers to feasible alternatives becoming mainstream options in aggregates and other use markets, considering local secondary availability and consequences of such policy change (Recommendation 8). When pursued in conjunction with principles of justice and equity (Recommendation 2), such efforts also assess the implications of policy and regulatory action or inaction for different groups in society, today and in future.

## Box 7 : Case Study - Why intersectionality matters in the formulation of strategic integrated policy & law (the case of Andhra Pradesh).

Intersectionality currently appears under-discussed in policy integration theory. It is discussed as an outcome, or as a means to improve policy formulation, but not specifically as an input to policy integration design and process. The case of Andhra Pradesh helps illustrate why intersectionality is a key ingredient along with vertical and horizontal integration efforts in governing sand resources.

Andhra Pradesh is a state in the south-eastern coastal region of India. Illegal sand mining has been reported in several districts within the states (Pallavi et al. 2013). In order to improve formalisation and legalisation, the state Government of Andhra Pradesh aimed to centralise the management of its sand resources and sand mining activities under the control of the Andhra Pradesh Mineral Development Cooperation. They took a strongly integrated and well-intentioned approach and linked this integration measure with an ambitious scheme to provide alternative livelihoods to women through the Development of Women and Children in Rural Areas (DWCRA). The DWCRA was created to empower and improve the quality of lives of women in rural communities living below the poverty line, namely by creating self-help groups for the women to identify sustainable opportunities to generate income.

The state government gave mining rights to the DWCRA women groups, who were responsible for managing and overseeing the delivery of sand purchased through a government online portal. Several pilot projects have been initiated in the state since 2014 (BusinessLine 2014). Out of the net profits earned, 25% would be directed to the DWCRA groups (Bikkina et al. 2017). Additionally, a monthly salary would be provided to the women. This initiative was the first to be implemented in India, aligned with the state's *Pedarikam Pai Gelupu*, or *Triumph Over Poverty* campaign.

Despite the initiative's ambition to reduce poverty and provide women with more opportunities, it has been plagued with many challenges that the state would need to address to fully realise its potential. Women reported delays in receiving their payments, some even resorting to paying with their own money to meet logistics requirements (ibid.). Health and safety were also a concern, where the women reported obstacles presented by political rival groups and risks to their personal safety from truck drivers at night. In addition, the women were not given proper training, even though training in matters such as financial planning, bookkeeping, and logistics and supply chain management were part of the state's New Sand Policy mandate.

The case of Andhra Pradesh therefore showcases an excellent instinct to both horizontally connect sand mining regulation improvements with gender and poverty outcomes, and to vertically integrate under one agency for improved implementation. However, this initiative still produced muddy outcomes because a missing intersectional lens. Taking into account the constraints and conditions that women face in this region as they seek economic independence and security would have allowed for these to be factored into the choice and design for intervention. Upfront considerations of women's experiences in this context might not have solved every problem, but it could have created opportunities to plan for actions to mitigate these risks and for a more secure progress on the multiple goals of improved sand resource management, poverty reduction and gender equity.

## Key actions

Five parallel actions for strategic and integrated policy and legal frameworks in sand and sustainability are relevant across most countries[11].

### Action 4.1 : Refine how policy problems and goals are understood ; set, and share common visions and rationalising mandates

The fragmented treatment of this resource in the policy and laws of many countries is explained by particularities of geologies and geographies; sources, types, and applications; and, in ways policy institutions have evolved to mediate access and use of these materials over long time frames in those places. Building a common understanding of the resource in the context of contemporary sustainability challenges is important before moving to update institutions. Five key tasks are:

- Analysing interdependencies connecting the production and consumption of sand and its alternatives to major issues of climate resilience, biodiversity, green and circular economy planning, urban and infrastructure, aggregates and construction, and waste management in context[12].
- Facilitating a transparent and shared overview of resource demand, availability, and materials flows, including understanding major use sectors and demand volumes; extraction sources, volumes, and methods for primary extraction; actual and latent availability from alternative sources; and demand reduction potential and realities.
- Identifying relevant policy domains, institutions, organisations, and mandates in context and characterising policy failures and successes with inputs from multiple stakeholders.
- Reviewing language, definitions, frameworks, and terminology to address fuzzy or lacking legal definitions which affects evaluation, design and implementation of policies and laws in many countries (UNEP/GRID-Geneva 2022a).
- Initiating cross-sectoral and multi-actor and stakeholder discussions to define problems and update agreed goals, objectives, and key results.

### Action 4.2 : Clarify who has a stake along the value chain and how actor goals, objectives and interests relate to one another

Successful framework and intervention design will depend on understanding who is affected by different scenarios for production and consumption of sand and its alternatives. This requires qualifying and quantifying effects distributed over different groups in society, upstream and downstream geographies, and time – taking their goals, vulnerabilities, and adaptive capacities into account if outcomes are to be both sustainable and equitable. Three core tasks are relevant:

- Identifying who is involved in and affected by consumption and production of sand and its alternatives today and into the future (Reed et al. 2009) using less traditional scales of ecosystems and ecosystem services (Sousa et al. 2020), key sectors and their value chains as well as cross-sector opportunities for circularity (UNEP 2022a), and the SDGs (Bendixen et al. 2021) for assessing sand consumption and production impacts to understand upstream and downstream consequences of policy action and inaction to supplement established EIA procedures (Recommendation 7).
- Identifying what institutions and actors have mandates and interests, power, and influence across policy domains critical to driving sand resources demand and utilisation (Hertin et al. 2003).
- Analysing compatibility between stated values, goals, and interests across stakeholder groups in national policy institutions, considering their influence on the agenda and conditions for effective integration of policy and legislative action (Candel 2021).
- Negotiating new goals, objectives, and key results within sustainability framings with viewpoints across different stakeholder groups, including an open consideration of the changes likely needed in environmental, natural resource and other institutions to support such goals.

11 The list of actions were produced through 1) knowledge synthesis of integration actions prepared by the lead author in (Bréthaut et al. 2019) and 2) and cross-referencing these actions against the outputs of a dialogue process co-hosted by UNEP/GRID-Geneva Global Sand Observatory and the Extractives and Development Sector programme of the German Federal Institute for Geosciences and Natural Resources (BGR) from July to September 2021. Policy actors, scholars and other practitioners who have recently produced place-based explorations on sand and gravel sustainability were brought together for online discussions on 1) policy structures, failures & successes in sand and gravel governance and management around the world, and 2) defining a just transition to a responsible sand governance and management. 38 participants discussed their experiences in 5 global regions and 20 countries including: Southern and West Africa; India; Lower Mekong Countries.

12 Emerging frameworks for Sustainable Development Goal interdependencies analysis are applicable here. For a recent review, see Alcamo et al. (2020).

### Action 4.3 : Design policy and regulatory institutions to coordinate actors that recognise the mix of formal and informal 'rules in use'

Structural factors inside and outside of formal policy institutions shape real-world behaviours and outcomes when it comes to policy integration (Ostrom 2011). Organisational forms and incentives for regulatory authorities (and individuals within) are particularly influential on success and failure. Three key tasks include:

- Understanding gaps in existing institutional regimes over different geographic and jurisdictional scales, stakeholders, and timeframes. Given the largely local and often informal nature of sand resource extraction, trade and use materials flows, the grey areas between legal and illegal, regulated, or unregulated, formal, and informal are to be treated carefully here.
- Reviewing existing policy structures to identify opportunities for: setting cross-sectoral policy directions and revising supporting legal frameworks accordingly; establishing or reinforcing administrative bodies with regulatory authority at appropriate levels; creating and reinforcing actor networks at strategic levels of decision making that affects materials demand and flows and improving monitoring and statistics.
- Assigning roles, responsibilities, and appropriate resources for a coherent regulatory environment in five critical areas : resource availability assessments, resource allocation and access regulation, alternatives production and adoption, impact assessment and monitoring.

### Action 4.4 : Improve alignment between public actor goals, objectives, interests, and mandates in practice

For policy actions to be compatible, non-conflicting, coordinated, complementary and mutually-reinforcing, improving alignment between goals, objectives, interventions, and resourcing, among other factors, is critical (Runhaar et al. 2014). Four key tasks include:

- Evaluating policy and legal instrument options for integration including but not limited to: mainstreaming action to normalise responsible sand sourcing and management into the routine activities of other policy domains (Scott et al. 2021); adjusting property rights regimes; reforming or instituting legal systems and legislative frameworks to clarify roles and responsibilities administrative bodies for the procedures and rules of decision-making, monitoring, enforcement and sanctions. Cross cutting mandates have led to neglect and lack of accountability on individual institutions.
- Simplifying policy and legal complexity.
- Creating enabling conditions and incentives for alternative materials experimentation, production, and market access for net positive sustainability outcomes.
- Resourcing authorities appropriately, including checking budget and financial incentives line-up with implementation and enforcement roles.

### Action 4.5 : Evaluate if policy actions are compatible, non-conflicting, coordinated, complementary and mutually reinforcing in reality

Current evaluation for sand-related policy activities falls short in many areas (UNEP 2019). 'Fit-for-purpose' approaches are ones that recognise the complexity inherent in local to regional sand value chains, the plural values in play, the imperative for systems transformation and the need for decolonised and culturally responsive evaluations. Three tasks for establishing appropriate evaluation commissioning and execution include:

- Defining clearly what good integration outcomes look like in the policy context in question.
- Revisiting guidelines and commissioning procedures for government policy evaluations to allow complexity-informed approaches[13].
- Creating opportunities in policy evaluation procedures to promote learning and adaptive planning across government levels, national line ministries and internationally, and operationalise sense-making and adaptive governance under uncertainty (Rowe 2021).

13 One example is: HM Treasury (2020).

## Box 8 : Case study - Multi-stakeholder Governance Approach in Makueni County in Kenya

A multi-stakeholder governance approach is essential in implementing strategic and integrated policy and legal frameworks governing sand resources. One sub-national example is Makueni County in Kenya.

### Background

Artisanal sand mining has historically been part of the economic bedrock of Makueni County, employing youth. Yet, unrestricted sand mining contributed to dried riverbeds and water scarcity, school dropouts, teenage pregnancies, drug and substance abuse, increased criminality, and violent conflicts over access and control of sand resources.

However, following strong citizen-led protests (Environment Justice Atlas 2018) against open-access sand mining in some parts of the County, the Makueni County Sand Conservation and Utilization Authority (henceforth the Sand Authority), was formed under the Makueni County Sand Conservation and Utilization Act (2015 ; Kenya, Makueni County Sand Conservation and Utilization Authority 2016). The Act's legal framework targets exclusively sand conservation and utilisation, i.e., the removal, extraction - or harvesting, as it is sometimes referred to in African sand resources discussions - of sand and restoration of degraded sites. This is operationalised through a dedicated government agency and a conservation fund.

### The main responsibilities of the Sand Authority are to :

- Enforce the ban on sand exports destined for utilisation outside the county.
- Regulate, licence, and monitor all sand utilisation activities within the county. It manages the mandatory EIA process and designates authorised extraction sites. Concession depends on the volume extracted, and only applies to sand mining above two tons. One reason for this volume threshold is to ensure that local communities can still access sand for residential construction purposes.
- Manage revenue and restoration projects. 50% of revenues derived from authorised sand extraction activities serve restoration and conservation activities. They include construction of sand dams in river zones previously exposed to environmental damages resulting from sand extraction.

**Sand dams constructions in Makueni County, Kenya**

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### Integrating communities into sand resources' management

The Sand Authority's participatory committees, namely the Ward Sand Management Committee and Sub County Sand Management Committee, are composed of civilians from various interest groups. These committees identify suitable sand extraction sites, help monitor harvesting and report suspicious and/or unauthorised sand activities to the Sand Authority. Their efforts in awareness raising help demonstrate to communities the benefits of regulated sand extraction (e.g., access to better water quality, reduced risks of drought, stable employment, social cohesion).

In line with this multi-stakeholder governance approach, the Sand Authority implements a national gender representation quota in its operations and decision-making (Republic of Kenya 2010). In ensuring women's effective participation and equal opportunities for leadership, the Two-Thirds Gender Rule applies across management and board committees, construction, and materials procurement policies. In the construction of Makueni County's sand dams, local communities, particularly women, supply raw materials and are engaged as remunerated semi-skilled or casual labourers.

### Replicability

Following the formation of the Sand Authority, the county has witnessed less violent conflicts over access and control of sand resources and a fall in school dropout rate. Water availability and riparian vegetation increased, facilitating the reuptake of small-scale agribusiness.

Yet, Makueni County's strategic integration of policy and legal frameworks faces significant challenges. The absence of a coordinated approach to regulate sand mining in Kenya's sub-national government institutions limits the socio-economic and environmental benefits in Makueni County. Given sand resources' transboundary nature, it is essential that sub-national government actions are complementary to achieve sustainability goals.

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# Recommendation 5 : Establish ownership and access to sand resources through mineral rights and consenting


## Summary

Having recognised naturally occurring sand as a nationally strategic resource, each country should understand its sand resources and develop strong governance through integrated policies managed by an authority with powers to guide (and devolve as required). To achieve the just, sustainable, and responsible sourcing of sand, a key step to delivery is the creation of an effective mineral ownership and access framework, extending onshore and offshore, which will also allow for a locally acceptable commercial mechanism for cost recovery.


Naturally occurring sand deposits are widespread, lie across and below the land surface and seabed, and have been valued for generations. Historically, access to sand deposits has evolved according to local needs, traditional practice, and national constitutions. This has resulted in a wide range of informal and formal approaches to accessing sand resources across the world which are in tune with the scale of extraction. Informal, consensual, or legalised access and extraction of sand resources is often dependent on a combination of separate interests related to property rights and regulation, but in countries where larger-scale extraction has occurred, a formal governance framework has often evolved. Adapting and applying the design principles established in existing sand ownership and access frameworks, in combination with new approaches to the management of natural resources, e.g., water (IUCN 2018), provides a sound foundation for improving the governance of sand resources.

### Box 9 : Learning from another natural resource - water rights and allocations.

Water resources have many similarities to sand resources - recent significant increases in demand have led to major changes in historical patterns of usage and the value of water. Often, water rights and allocation practices already exist but may be unclaimed, unrecognised and sit within immature or weak legal frameworks. Water resources have other similarities to sand resources including their distribution - extending underground and across jurisdictions (e.g., along rivers); suffering localised depletion; having no mechanisms for taking a strategic overview, being subject to a range of competing demands; a limited knowledge of the resource and a wide range of public and private stakeholders. Water has been recognised as a strategic resource before sand, and as a result water resource rights and allocation have been explored and investigated over the past two decades and longer. Water resource management provides perspectives, analogies and approaches that may be usefully applied to the sustainable development of sand resources, including the mapping of rights (Miller et al. 1997), application of principles-based approaches[14], models of constitutional reforms[15] and a range of economic instruments (Rey et al. 2019).

14 For example: the Dublin Principles (Solanes and Gonzalez-Villarreal 2008).
15 For example: Magawana (2021)


## Rationale

Naturally occurring sand is found across the earth's surface and extend underground, as three-dimensional bodies of sediment which respect no anthropogenic boundaries such as territories, jurisdictions, administrations, product markets or habitats. We therefore have to impose an 'unnatural' governance regime which crosses space and depth (below the earth's surface) related to territories and is unconnected to natural processes of erosion and deposition (see Box 1). Sand ownership and access has been traditionally delivered through a system of informal or formal mineral rights (awarded by a government or the mineral owner) which may be associated with regulation and consenting frameworks.

Until recently, sand sourcing for development has often been a local issue, typically operating within the environmental capacity of the area. Arrangements for accessing sand resources have been:

- fit-for-purpose, effectively serving the local and regional needs of economies and communities, and
- environmentally acceptable with impacts constrained by the relatively small scale of extractive activities.

The rapid increase in population (especially in Asia and Africa), an appetite for an increase in living standards driving urban development, the growth and upscaling of infrastructure, combined with an adaptation to climate change (Recommendation 1) has driven the demand for sand to unprecedented levels. Satisfying this demand has led to increased sand extraction from both existing sand deposits and from new, previously unexploited deposits[16].

The growth in sand extraction has created an imbalance—a market failure—testing both existing sources and the established supply structures which have not been created to ensure sustainable development at the current elevated levels of demand. This demand has also amplified and exposed our weak understanding of the distribution, scale, and quality of our sand resources.

In some places, governance regimes designed to oversee the management of sand as a strategic natural asset address the balance of supply, planning and environmental management of activities associated with sand resource extraction, and have evolved in step with the increased development of the resource (see Box 8). In contrast, countries where formal legal ownership and consenting frameworks are weak or do not exist, access to resources has grown organically and may be strongly influenced by personal factors where resources are utilised in an unsustainable and potentially highly damaging way until their depletion.

Taking an economic perspective, ineffective management of sand supply may result in delay and cost. Where this demand is not being satisfied, the illegal, uncontrolled, and unregulated supply of sand associated with criminal activity may develop, with significant adverse social and environmental impacts. Furthermore, the conflation of conflicting ministries, immature legislation and traditional practices aggravate the current unsustainable situation.

One option that can be taken as a first step in the sustainable management of sand sources and supplies is the creation of an ownership and access framework which can be delivered as three interconnected actions. Under these terms, sand resource development would require enforceable agreements with both the owner of the mineral rights, and a consent which permits the sand extraction to proceed.

16 For example, marine sands for reclamation and coastal adaptation.

## Key Actions

### Action 5.1 : Create a legal framework to establish mineral ownership rights on a national scale extending onshore and offshore

- Mineral rights underpin the governance and management of sand resources by establishing ownership of the resources that is lying on, or under, the land (or seabed), and the granting of a right to directly benefit from its extraction[17].
- Mapping and understanding the existing range of mineral rights, responsibilities and practices provides the basis for recognising existing interests and considering options. E.g., should rights lie under private, common (community) or state (government) ownership ?
- The establishment and introduction of a comprehensive national, enforceable legal framework for mineral rights can allow controlled access to sand resources.

The establishment of mineral rights is one part in regulating access to sand resources. Resource management is required as uncontrolled access to these rights driven by market forces is not necessarily aligned with a sustainable development ambition. Whereas access to sand is a traditional right in some places, obtaining the agreement to extract and use a sand resource from its owner is often the subject of a legal and commercial arrangement. Awards of rights by owners to developers wishing to extract sand may be exclusive (to a single extractor) or non-exclusive (to several extractors)[18]. It is important to recognise that the value of obtaining rights to sand resources is influenced by many factors, including its location, quality, and scarcity (relating to its use), extractability, proximity to emerging development and the availability of alternative resources. If commercial rights to extract sand are secured, the successful bidder has an established advantage over competitive suppliers with a less attractive stock.

### Action 5.2 : Create a locally acceptable commercial mechanism (royalty or levy)[19] through a mineral rights framework that enables recovery of operating costs

- Sand resources are managed publicly by the government or through a private mineral ownership model.
- The commercial right to access sand resources is intended to produce benefits and/or financial returns to the mineral owner.
- A royalty or levy should be applied for the use of state-owned minerals or private mineral owners at a level (for example by volume) that fully recovers national sand resource management costs.

In countries where sand resources are managed publicly by the government, or where a private mineral ownership model is established and enforceable, sand resources may either be allocated to projects by government or alternatively the commercial right to access sand resources should take place through a transparent open process where competition is intended to produce benefits and financial returns to the mineral owner. Motivation of mineral owners vary – for example financial returns may be aligned to recover resource management costs (often state-owned minerals) or to maximise returns (private owners). Looking ahead, as the strategic value of sand as a critical resource is recognised, the costs incurred for the national management of sand resources should be recovered from users that benefit from the sand resources. For example, in the case of government (public project) procurement of sand resources, the costs of sand management should be funded internally within the government. In contrast, a proportion of the fees for the private right to extract sands should also contribute to the national management of sand resources[20].

### Action 5.3 : Establish a national regulatory and consenting regime based on a sound understanding of sand resources and principles of sustainable management, applicable onshore and offshore

- Development of sand resources should be contingent on successfully obtaining an independently assessed consent, i.e., a permit to extract.
- The consenting framework should recognise and balance the wider interests of government and sustainable sourcing.
- Such a consenting framework should be established independently of a mineral rights framework (Action 5.2).

Sand regulation and consenting frameworks often form a complex administrative landscape with a range of cross-cutting and interfering responsibilities and interests[21].

17 Subsurface mineral rights may be separate from land ownership
18 In some places sand is deliberately carved out of a mineral rights regime as it has been traditionally viewed as a low value product.
19 Fees or a levy are commonly proportional to extraction – for example charged on a tonnage basis.
20 Private commercial rights to extract sand may require a bi-lateral negotiation or have to be won through open market competitions using mechanisms such as tendering, where invariably the highest bidder wins the non-exclusive or exclusive right to extract sand from: a defined area, period, total volume, rate of extraction and royalty rate (price per ton or equivalent), and in accordance with a consent and subject to local conditions applied by a regulator – for example planning, social (e.g., disturbance by trucks, noise etc..) and environmental restrictions.
21 E.g. In the UK, sand resources are cross governed by multiple national line ministries. In the absence of a formal national mineral strategy, the UK mineral industry proposed a Minerals Strategy in 2018, which sets out the social, environmental, and economic issues that will need to be addressed to ensure sustainable supplies of minerals to 2050 (MPA 2018)

In combination with a rights framework (which may be commercial), development of sand resources should also be subject to consent which recognises and balances the wider interests of government and sustainable sourcing. A consent provides the legal permission to extract a sand resource given by the relevant competent authority operating within the context of local, regional, and national government policies. A number of relevant policies may link sand supply with (i) economic development (e.g., construction and specialist products); (ii) environmental protection (e.g., EIA[22] and conservation) and (iii) planning (e.g., zoning of preferred resource development areas balancing the full range of socio-economic interests applied on a local to national scale to ensure a long-term sand supply and regional allocation of sand sourcing targets).

At national scale, very often there are also separate policies for the management of terrestrial and offshore resources and activities[23]. In addition, in some places some consenting decisions are made by a national authority and in other places decisions are made locally[24]. Typically, a responsible authority (regulator) grants operational consents within a legal framework, monitors extraction, and delivers enforceable regulation. Consent to extract sand deposits is commonly subject to a series of conditions including limitations of volumes, timing, extent, extraction techniques, environmental disturbance as well as the restoration of sites. Successful consenting requires:

- The creation of local, regional, and national government policies and a competent authority that will ensure continued supply of all (onshore and offshore) sand will be delivered through the sustainable development of resources; and
- Regulation and consenting controls to be delivered through planning, taking account, and balancing the full range of socio-economic interests (e.g., the identification of preferred sand resource development areas, resource management to ensure a long-term sand supply and regional allocation of sand sourcing targets), environmental assessment of development proposals and monitoring of environmental performance.

## Box 10 : Alternative Naturally Occurring Sources & Marine Sands

In many places, increasing demand has led to sand extraction at unprecedented levels from both existing sand deposits and from new, previously unexploited deposits, for example, marine sands for use in reclamation and coastal adaptation.

Significant volumes of sand resources occur in saline and submarine environments often lying close to the shoreline in deltas and estuaries[25] at shallow depths of a few metres but also extend many tens of kms offshore where deposits typically lie at depths of up to 100 m. Traditionally, these deposits have been inaccessible and difficult to extract, and despite commonly lying close to centres of population, have been extracted only locally and in limited volumes. As a result, typical management frameworks around rights and development of marine deposits are immature and less well developed than adjacent land-based sand deposits[26].

As pressure has mounted on existing terrestrial sand resources, the last two decades has witnessed a dramatic upsurge in the demand for marine sands in use for construction, land reclamation, beach nourishment and coastal adaptation:

- In construction, marine sands may be used alone or blended with marine gravels, land-based gravels or crushed rock to make concrete and other concrete products;
- Expansion of coastal cities and ports through land reclamation is based on the supply of marine sands that can be efficiently delivered in substantial volumes by dredgers, which have evolved and scaled-up to the extent that tens of thousands of tons of sand can be delivered to a site daily; and
- Threats to low lying coastal communities and infrastructure from climate change has resulted in the denudation of beaches, which are now routinely supplied with marine sands to replace losses and enhance coastlines' resilience.

Although several countries have highly developed regulatory marine sand extraction regimes, practices vary widely across the world. In many countries different laws apply offshore and although the state often owns the seabed out to the limit of its EEZ, many countries have not asserted their mineral rights beyond their territorial seas and introduced legislation around the extraction and management of their marine sand resources.

22 Noting that if costs are a constraining factor, EIA of a proposed development may also be undertaken at a regional scale or on a strategic basis.
23 Across the Exclusive Economic Zone (EEZ).
24 According to the principle of subsidiarity – where decisions are made locally (Recommendation 2).
25 Estuaries form where rivers meet the sea and deltas consist of river sand deposits lying in estuaries.
26 Noting the IUCN's call for the urgent global management of marine and coastal sand resources (IUCN 2016).

# Recommendation 6 : Map, monitor and report sand resources


## Summary

Recognising unprecedented demand for sand to fulfil strategic needs, resource mapping is required, locally, but also at (supra)regional scales. Extraction in huge volumes causes adverse impacts on the environment (SDG 2, 6, 13, 14, 15), and affects economic and social development. Jointly weighing geological, environmental, and socio-economic parametres is therefore paramount for informed decision-making. More systematic comprehension of connections and mutual dependencies within a coupled human-natural system further serves achieving sustainability in an interconnected world. Data and science are hence critical for decision-making.


The sustainable management of sand resources requires a thorough and careful balancing of available quantity and quality of sand versus rapidly changing societal and economical needs. Sand is, in volume, the main solid material used by humans; yet there are, for most countries, no reporting mechanisms in place to monitor its use, locations of extraction and demand by sectors. Comprehensive knowledge on occurrence and distribution, composition, and dynamics, in combination with environmental impact of extraction, is therefore critical for developing long-term strategies for optimised resource use. Multiple criteria, including technical feasibility, further constrain the total 'theoretical' availability (resource) into extractable quantities (reserve) requiring suitable resource management tools for realistic predictions of a safe and secure supply.

With increasing development needs, society will need more and more sand. Meanwhile, other activities grow as well, with spatial planning best serving allocation of space. Quantification of strategic needs, and an assessment of environmental and socio-economic impacts (Recommendation 1), are the basis to set country- and region-specific policies, put in place legal and economic measures and develop technical alternatives. These needs call for transparent data and analytical frameworks to inform decision-making.

## Rationale

Globally, the sand supply base is not known, and only aggregate production estimates are available (Table 5). However, long-term availability and supply of naturally occurring sand and gravel should not be taken for granted, which is already exemplified by shortages on the short- to medium-term (Ioannidou et al. 2019). This is related to the uneven distribution of geological resources: (1) deposition being region- to site-specific in terms of quantity, and (2) the sand quality being largely dependent on the geological process of its formation (e.g., fluvial, coastal, marine, or glacial processes). However, irrespective of the geology, there is increasing competition for space to extract and areas with restrictions are only increasing (e.g., for nature conservation). From the above, there is a growing need for data-driven resource management using most appropriate tools. Spatial planning is highly recommended to cope with multiple (sub)surface-related activities.

Very few countries know with enough detail the extraction quantities per year, the uses, and related environmental and socio-economic issues. A lack of data and information, combined with several other socio-political drivers such as limited regulation, often lead to illegal/informal/unregulated sand mining having potentially large negative environmental and social impacts. By providing data and maps of sand resources and land use, alternatives can be considered, and choices can be made to opt for a fair and just sand product.

**Table 5 : Global aggregates production estimates (Mt : million metric tons) for the years 2020-2021**

| | 2020 Mt | 2021 Mt | Change |
|---|---|---|---|
| World | 42,211 | 44,300 | +4.9% |

Source : Global Aggregates Information Network (O'Brien 2021)

## Key actions

### Action 6.1 : Invest in strategic resource mapping to secure long-term and safe supply of sand

- Recognise that sand resource needs are diverse and application/actor-specific, with growing environmental conditions to be fulfilled, requiring multidisciplinary mapping of resource quality and quantity.
- Secure long-term and safe supply through strategic planning, identifying short- to long-term availability while safeguarding natural capital.
- Build capacity for implementation at the regional scale, calling upon Geological Survey Organisations to coordinate the actions, and build versatile databases allowing actor-specific resource evaluation. Remote sensing capabilities should be further exploited to deliver resource-relevant information, especially in areas with no data.

Recognising that globally sand resources in many areas are yet unmapped, while the needs are unprecedentedly rising, there is momentum to engage in strategic resource mapping. Geological Surveys are best placed to coordinate the actions given their knowledge on the geology, mapping know-how and increasing structural initiatives for joint mapping (e.g., OneGeology (British Geological Survey 2020); the envisaged Geological Service for Europe (Vidovic et al. 2020), USGS Earth Mapping Resources Initiative (Day 2019). To increase data availability, a centralised registration of subsurface information (e.g., boreholes) when executing public works (Meulen et al. 2013) can be legally mandated. On a global scale, public-private partnerships can be set-up to share data and information (e.g., similar to (Seabed 2030 n.d.) for bathymetry). Governments can stimulate strategic planning to ensure maximum security to the extractive industry while safeguarding natural capital (Recommendation 6). State-of-the-art mapping technology allows multidisciplinary resource mapping depicting most efficiently a vast range of geological and environmental parametres at once. Remote sensing (e.g., via ESA-Copernicus (European Union's Earth Observation Programme 2021), (NASA-NEO n.d.)) delivers increasingly resource-relevant data, and global coordinated Earth Observation efforts such as the GEO/GEOSS initiative (Group on Earth Observations n.d.) could play a major role. Examples include the mapping of near surface geology (European Association of Remote Sensing Companies 2020), sand distribution patterns (Conger et al. 2009) sustainable aggregate supply (Lavender 2021), and remote identification of sandy coastlines worldwide (Luijendijk et al. 2018). Although resource quantity estimates still require on-site geological approaches, morphological and topographical analyses of remotely sensed digital elevation models may allow a first delineation of important sand resource areas. To fulfil future needs, reliable quality and quantity estimates for land, rivers and sea are needed due to growing land-use constraints and depletion of easily accessible terrestrial sand resources. These estimates are best based on common classification standards and derived from coherent modelling approaches. Seamless land-sea 3D geological models are optimal, fed by a multitude of resource-relevant information (Box 11). Overall, the better the models and the maps, the better the environment can be safeguarded.

### Action 6.2 : Conduct monitoring and research to mitigate environmental impacts (Also refer to Recommendation 9)

- Implement a holistic environmental impact assessment (EIA) process for larger sand mining projects to identify the effects on the environment and on human health and welfare.
- Design monitoring programs adapted to the nature and dynamicity of the environment.
- Fund research to build understanding of the processes underlying environmental changes to avoid and minimise adverse impacts.
- Capture traditional and local knowledge to safeguard valuable ecosystem services upon which livelihoods are built.

Many environmental impacts can be avoided or minimised with increased understanding of the environment. However, to support effective management, there is a need to collect scientific evidence on how sand mining is affecting ecosystem services and functions, threatening biodiversity, and how these impacts interact with other activities or threats (Koehnken et al. 2020). In river and shallow marine environments, knowledge on system dynamics is important to understand the up- and downstream effects of extraction. Hydrology, sand budgets, geomorphology, and ecology interconnect and matter within impact assessments, and therefore require a historical perspective, human use management, and hydrological connectivity at the catchment scale (Newson et al. 2021). This calls for holistic environmental impact assessment frameworks based on best available knowledge.

### Action 6.3 : Develop multi-criteria resource evaluation tools that are based on availability, environmental and socio-economic impacts

- Improve classification of sand resources at a regional scale, including the socio-economic and environmental dimension (e.g., following the United Nations Framework Classification (UNFC) for mineral resources).
- Embed such classifications into multi-criteria decision-support systems to allow for the consideration of diverse and complex interests and build knowledge bases supporting long-term adaptive resource and environmental management.
- Project strategic needs into scenario analysis for strategic planning and decision making.
- Increase efficiency in resource use, e.g., targeting the right quality for the desired purpose. Valuable coarse sands should not end up in low-end products, and undesired admixtures (minimising waste) should be avoided pro-actively.
- Promote spatial planning to minimise conflict in a multi-use environment (e.g., sealing of significant resource reserves by other human activities). Multiple use of the subsurface further requires subsurface planning and management.

Strategic resource allocation and decision-making best builds on a synthesis of mapping and monitoring, as well as socio-economic evaluation against strategic needs in a multi-use context (e.g., securing resource supplies for new infrastructure, but also grand nourishment schemes to safeguard low-lying coastal areas). Considering processing needs and transportation cost (i.e., related to distance, and $CO^2$ emissions) further stimulates local consumption.

Multi-criteria decision-support tools, and particularly the international resource classification standard UNFC-2009 (UNECE 2010), allow to combine information on environmental and socio-economic viability, technical feasibility, and degree of confidence in a structured way (UNECE n.d.). UNFC is particularly promoted as a valuable tool for a holistic assessment of natural resources, with recent case studies on sand use, both for land and the marine environment[27]. Spatial planning is recommended for the optimal allocation of space. When based upon reliable estimates of the quantity and quality of the resource, the sealing of significant resource reserves by other human activities, including other subsurface applications (e.g., energy, $CO^2$ storage), can be avoided. The objective is to ensure that extraction takes place in a safe, secure, affordable, and environmentally friendly manner.

### Action 6.4 : Recognise that naturally occurring sand and sand resources also require integrative and predictive science to meet society's needs

- Invest in gaining a more systematic comprehension of linkages between the use of sand resources, and its environmental and socio-economic outcomes to achieve sustainability in an increasingly interconnected world (Torres et al. 2021).

Securing the provision of sand resources is widely overlooked in existing vision documents on mineral resources, as well as in resource monitoring frameworks. Still, given the huge volumes involved, and the strategic needs, a similar call for more integrative science, holistic environmental assessments and prediction capabilities exists[28]. A greater interdisciplinary integration should aim at understanding the interconnectedness between ecosystem components, whilst transdisciplinary research involving non-natural sciences and stakeholders is needed to address the sustainable transitions in the sand-supply network, i.e., how society can cope with doubling demands, whilst still securing supply, maximise resource efficiency and aligning with the planetary boundaries and SDGs (Torres et al. 2021).

27 See for example the European Union's Horizon 2020 research and innovation programme GeoERA, project Mintell4EU (GeoERA 2018).
28 See for example U.S. Geological Survey 21st-Century science strategy 2020–2030 : https://pubs.er.usgs.gov/publication/cir1476 (US Geological Survey 2021)

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**Action 6.5 : Develop strategic resource accounting and reporting along the full production-consumption chains going from extraction, use in products (e.g., concrete), transportation to end-of-life**

- Agree on common language on terms and definition allowing consistent accounting and reporting at the regional to global scale (UNEP/GRID-Geneva 2022a ; 2022b).
- Improve the way sand and gravel is considered in the UN's System of Environmental-Economic Accounting (SEEA), as well as in trade and goods classifications.
- Improve how sand and gravel are considered in resource accounting frameworks such as Material Flow Analysis (MFA)[29].
- Develop an integrated environment-social framework based on Life Cycle Assessment (LCA) for the sand and gravel industry including full supply, use and end-of-life chains.
- Develop Life Cycle Impact assessment methods to clearly assess the environmental damages induced by sand extraction in fragile environments.
- Develop risk assessment frameworks to help countries identify potential hotspots from a resource-economic-social-environmental perspective.
- Develop reporting frameworks to help countries monitor and report on sand extraction and use.

To deal with increasing sand consumption, there is a need for better data, better reporting, and analytical frameworks. Such a holistic perspective allows carefully evaluating potential solutions and understanding undesirable side-effects, e.g., a displacement of the problem along supply chains or elsewhere in the world, as well as the generation of other types of environmental impacts (e.g., additional emissions of GHGs increasing climate change). Such an understanding requires developing publicly available, clearly documented datasets and assessment procedures following the FAIR principle (findable, accessible, interoperable, and reusable) and best practices for data quality. Developing such an understanding also means that reported data (e.g., by countries and industries) and modelled data (e.g., by research institutions) should be used in parallel.

From an impact assessment perspective, a suite of environmental systems analysis tools exists (e.g., SEAA, MFA, LCA) (Finnveden et al. 2005). These require understanding and generating an inventory of the full production-consumption chains going from sand extraction, use in products (e.g., concrete), transportation to end-of-life. Furthermore, the inventory of sand flows should be connected to environmental and social impact assessment methods to quantify the induced impacts in terms of climate change, biodiversity losses or use of child labour, for example.

29 E.g. in the Global Material Flows Database from the IRP : https://www.resourcepanel.org/global-material-flows-database (IRP n.d.)

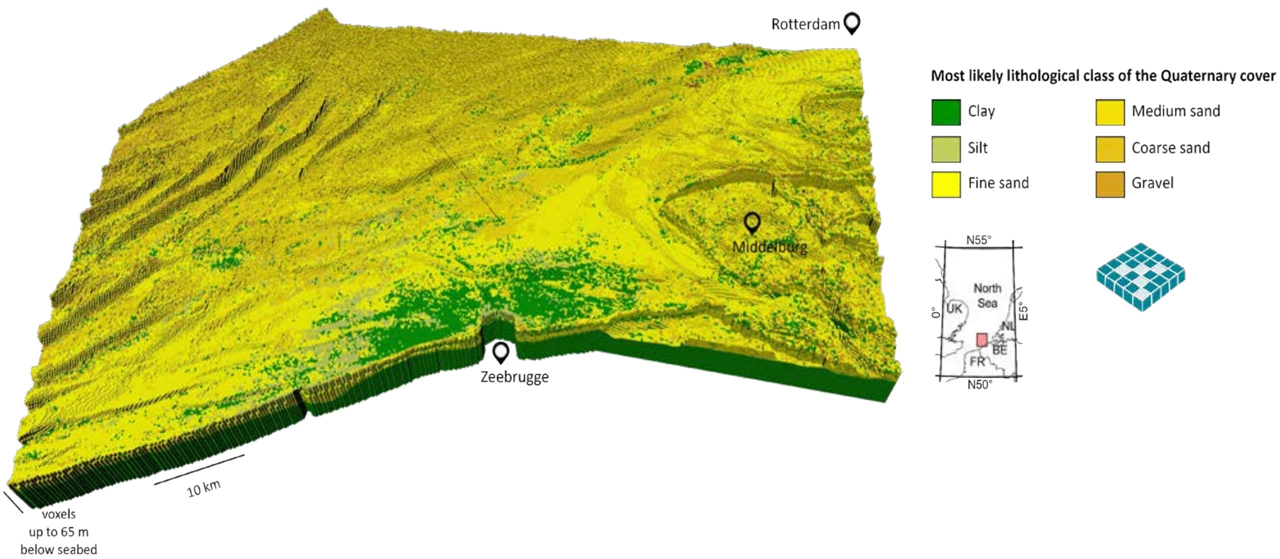
## Box 11 : Case study - Innovative 4D management of sand resources in the Belgian and Netherlands part of the North Sea

Socio-economic demands for marine sand resources in the North-East Atlantic have increased at an unprecedented pace (ICES 2021). During the past few years, hundreds of millions of $m^3$ of offshore sand and gravel have been extracted for coastal maintenance, extensions and industrial use. Future demands will be even higher to anticipate an accelerating sea-level rise and to realise large infrastructural works in coastal and offshore (e.g., to produce energy) settings. Some of these developments are incorporated in Marine Spatial Plans, though their full implementation depends on a sustainable supply of sand.

To ensure a safe and secure supply on the long term, a 3D voxel model (volume pixels) was built for the surface and subsurface of the territorial seas and exclusive economic zone of Belgium and the Netherlands (south of Rotterdam) where overall the Quaternary cover is relatively thin (Van Lancker et al. 2017 ; Van Lancker et al. 2019). This approach was chosen because of the high spatial variability in quantity and quality of sand which would be hard to capture in maps. Standardised and harmonised databases were created with metadata allowing the estimation of data-related uncertainty (Kint et al. 2021). Data were entered at the highest detail to maximise classification to any application (e.g., aggregate industry, biodiversity). The methodological workflow for the 3D modelling, using seismics and boreholes in a marine setting (Hademenos et al. 2019), built upon extensive voxel modelling experience on land (Stafleu et al. 2014). The 3D models were further coupled to 4D numerical environmental impact models to quantify environmental impact under various scenarios of extraction. Data, models, and their uncertainties, were embedded in an end-user driven decision support system (DSS) allowing querying the full 3D resource volume and integrating it with third-party data. From a management perspective, the DSS allows for long-term resource management, balancing quality, and quantity data against various applications, while minimising environmental impact (Wyns et al. 2021). For Belgian waters, a renewed policy is now in place, which imposes a lower limit of extraction based on resource thickness and characteristics, as well as criteria related to seabed integrity and hydrographic conditions (Degrendele et al. 2021 ; Federal Public Service Economy, Continental Shelf Service n.d.).

The model (Map 1) provides information on the quality and quantity of the Quaternary sediments, confirming the predominance of fine sands in the coastal zone, shifting towards medium sands in the offshore region. Products are further valorised into the European Marine Data and Observation Network (European Commission 2021a), comprising information on mineral resources, including their volumes where available. DSS application development is further projected in the future expansion of the (The Geological Surveys of Europe 2021). Meanwhile, 3D geological modelling and the move towards 4D has become mainstream in Geological Surveys worldwide (Culshaw et al. 2021).

**Map 1 : Transnational subsurface resource model of the Quaternary sediments of the territorial sea and exclusive economic zone of Belgium and the Netherlands (south of Rotterdam).**




Source : (Van Lancker et al. 2019 p.32)

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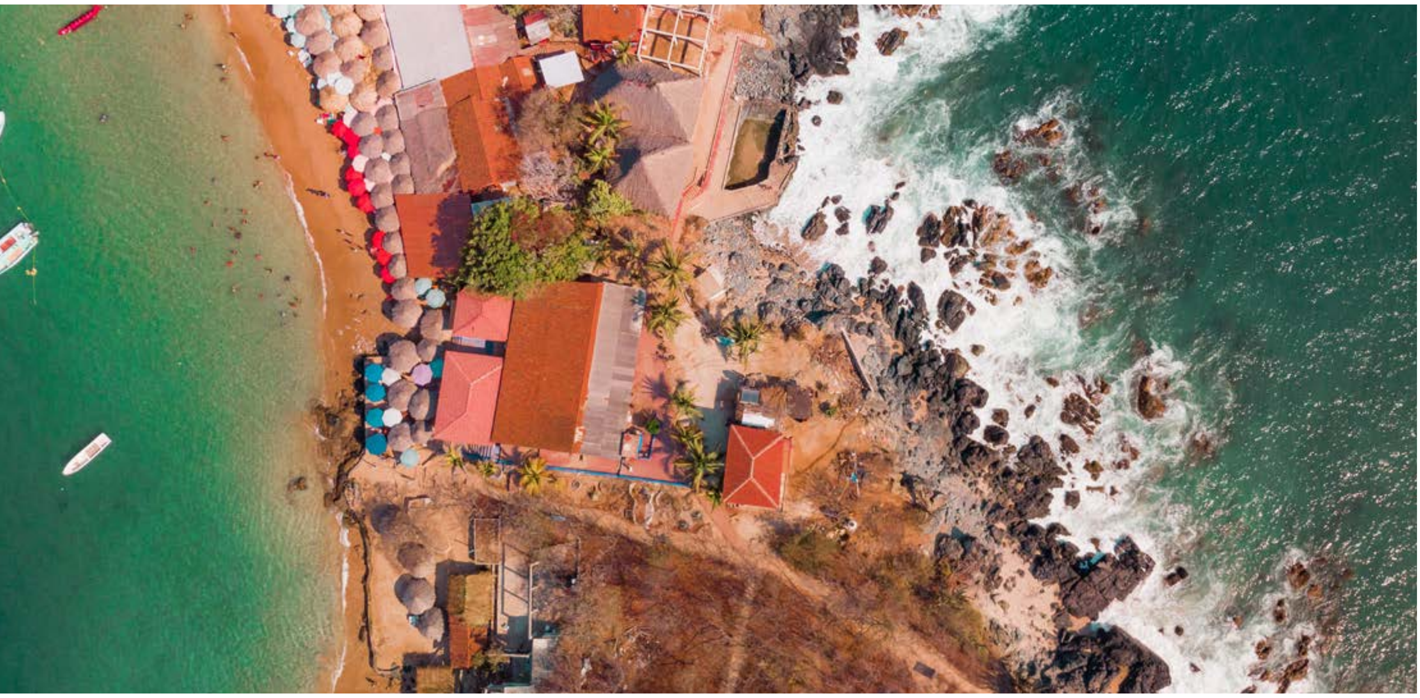

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# Recommendation 7 : Establish best practices, national standards, and a coherent international framework


## Summary

Various practices, standards and guidelines exist on how to extract and use sand whilst minimising the environmental impacts. Yet, these practices, standards and guidelines are not sufficiently shared and tested at the multilateral level. Unlike water, there is currently no integrated holistic approach to sand as part of both the natural and the built environment, as an extractive resource and as a building block for new products. Some steps towards integration have been made through a growing number of guidelines on nature-based solutions. However, any updated and integrated guidelines or standards should take into consideration the value that sand brings to natural processes and other uses. Changing where and how we extract, remove, or use sand can significantly help with the preservation of our environment and make our industries more efficient and sustainable.


## Key Actions

### Action point 7.1 : Establish, centralise, and encourage the use of best practices for the primary sources of sand.

While best practices and guidelines with common themes already exist for various countries and regions, there is a need for a centralised database for the primary sources of sand (Table 6). It is recommended to governments, local authorities, and the extraction industries to:

- **Collect and share best practices, guidelines, and monitoring plans for primary sources of sand** including (1) rock quarries (2) terrestrial sand deposits (3) the riverine and lacustrine environment, (4) the beach systems and (5) the marine environment (Table 6). While acknowledging that regulatory frameworks differ by national, regional, and local contexts, the principles driving good practices can still provide a sound basis for application across countries and natural environments.

- **Ban sand extraction for the purpose of mining sand as a resource in the active beach-nearshore sand system**, which includes the beach and the part of the nearshore environment involved in the sediment transport to and from the beach. This environment is particularly vulnerable to the impacts of sand mining and of great importance in terms of coastal resilience, the environment, and the coastal economy.

- **Establish an international standard on sand extraction in the marine environment**[30]. Unlike terrestrial sand extraction, coastal and marine dredging projects are usually awarded through public tenders open to international companies. Having an international standard which can be used across the globe in public tenders could therefore strongly improve extractive practices (see also Recommendation 9) and strengthen global efforts to protect the marine environment.

30 The marine environment is a dynamic environment consisting of both inactive and active deposits (Box 1).

| Table 6 : Primary sources of sand | |
|---|---|
| **Rock quarries** | Crushed rock is the most important alternative to sand and gravel extracted from the natural environment. The environmental impact of extraction tends to be relatively localised but can have important impacts on aquifers and/or habitats for endangered species. Rock quarries and crushing facilities are capital intensive and consequentially, are often more closely monitored and regulated. Guidelines and good practices with a clear description of the environmental conditions could further improve sustainable practices around the world[31]. |
| **Terrestrial sand sources** | Most terrestrial environments are static with notable exceptions (e.g., dunes). For static environments, environmental impacts from extraction tend to be localised. Extractive practices range from labour intensive sand pits to capital intensive sand quarries. The very low capital and technical threshold to extract this terrestrial resource makes sand extraction challenging to control for public authorities. Large-scale uncontrolled extraction could have significant environmental consequences to e.g., groundwater and agricultural land. Good guidance and training at local level on how to avoid and/or minimise negative impacts is necessary and could help local authorities monitor extractive activities and train miners on the ground[32]. Some countries, including India, already provide such guidelines (India, Ministry of Environment, Forest and Climate Change 2016). |
| **The riverine and lacustrine environment** | River extraction, and any activity altering the sediment transport or the hydrodynamic conditions, can induce changes to the river with far reaching consequences up-stream, down-stream, and in-situ. River extraction tends to be relatively cheap and accessible, using shovels, pumps, or excavators. Even when licenced, the over-extraction of the riverine environment tends to be difficult to monitor. In-channel sand mining is therefore banned in many countries and extraction from floodplains tends to be restricted. Where sand extraction from rivers cannot be avoided, EIAs and strict guidelines should be provided in combination with close (and often costly) monitoring to ensure that (1) the river remains in equilibrium with its environment, (2) water quality does not deteriorate, (3) no excessive riverbed and bank erosion is induced and (4) induced sediment deposition remains limited in particular around existing infrastructure. Some countries already provide such guidelines, including Malaysia (Salahuddin 2009 ; Malaysia, Environment Protection Department 2012) and India (India, Ministry of Environment, Forest and Climate Change 2016). |
| **The active beach-nearshore sand system** | The active beach-nearshore sand system includes the beach and the part of the nearshore environment involved in the sediment transport to and from the beach. Sand resources are essential for coastal dynamics. This environment is therefore very sensitive to the environmental impacts of sand extraction. A healthy and functioning coastal area is generally the most cost-effective and long-term defence in coastal resilience strategies (Figure 2). Moreover, coastal areas are important to maintain fish stocks, provide a habitat to plants and many endangered species, and are of key economic value for many industries. Thus, sand mining within this system has severe consequences. Guidelines for minimising the impact of dredging activity in the context of coastal restoration, coastal resilience and necessary infrastructure works should be in place and adopted across coastal regions, all of which could benefit from an environmental standard. |
| **The marine environment[33]** | Marine sand extraction changes the bathymetry, i.e., the depths and shapes of underwater terrain. If done without the necessary precautions and expertise, this can alter sediment transport, the strength or direction of water currents and the size or direction of marine waves. Marine sand extraction can thus lead to wide scale environmental changes, including sand supply to coastal areas. Furthermore, sand extraction at the seabed impacts the flora and fauna, micro-organisms, marine food chain, biodiversity, and fisheries (Peduzzi 2014). The implications for marine and coastal environments are recognised by the IUCN, calling for "the urgent global management of marine and coastal sand resources" (IUCN 2020c). Marine sand mining for any use other than marine and coastal works is banned in several countries. Marine extraction is capital intensive, tends to be highly specialised and is often an integral part of infrastructure and coastal management. Good guidance already exists but also needs to be implemented[34]. |

31 See namely the guidance produced for the cement and aggregates sector (IUCN 2020a)
32 See namely IRMA's certification process for responsible mining (Initiative for Responsible Mining Assurance 2021).
33 The riverine environment includes the river channels, the riverbanks, the levees, estuaries, deltas, and floodplains.
34 Ample guidance documents exist: (International Council for the Exploration of the Sea 2003; British Marine Aggregate Producers Association and The Crown Estate 2013; Group of Experts on the Scientific Aspects of Marine Environmental Protection 2019).

### Action point 7.2 : Promote regular updates of technical standards for materials and building infrastructures

The traditional role of technical standards is to make sure products meet certain quality requirements for specific purposes. These standards often result from different building/production traditions, which are strongly tied to locally available raw materials. However, the availability of accessible sand resources evolves constantly as a result of new technologies, spatial planning, and the depletion of local resources. Various standards have lost connection with the local availability of sand resources, and this comes at an environmental cost. For example, in some sand-scarce regions, national standards explicitly call for the use of naturally occurring sand without allowing or encouraging the use of alternative materials such as recycled materials (Recommendation 8).

Moreover, it is also common in infrastructure projects to refer to older outdated standards which restrict the use of new technologies and/or materials.

It is therefore recommended that governments and standards organisations:

- Ensure that national standards are updated regularly, remain sustainable in their geographical context, and allow for new and more sustainable practices.
- Ensure that national standards are performance-based, rather than prescriptive in terms of technical and environmental criteria.
- Include environmental experts and providers of new technologies in the standards making process.
- Encourage the latest technical standards to be applied by the industry.
- Encourage the industry to consider local environmental impacts and resource availability, even when working in accordance with required technical standards.

### Action point 7.3 : Identify best practices for industry and infrastructure that recognise the environmental and economic value of sand

The use of sand and the natural sediment cycle is currently dealt with in a very siloed way; each industry or sector considers its own needs without taking into account the bigger picture. Available sand resources are, as a consequence, not used optimally and/or without environmental and socio-economic considerations and the needs of other sectors. Sand resources are not only impacted through direct use, but also through indirect use and modifications to the natural pathways of sand such as in rivers. It is recommended that governments and the industry at large:

- **Identify practices to minimise the environmental impact of infrastructure that alter the natural pathways of sand.** The impoundment of the sediment by infrastructure along rivers and coastlines is often undesired and has a profound environmental impact. For example, the sedimentation behind dams reduces the global annual supply of sediment from land to ocean by 25-30% and negatively affects the operation of those dams (Vörösmarty et al. 2003 ; Walling 2012). Various solutions exist for different types of infrastructure. Often, they result in a higher upfront cost or operational costs but usually will generate long term gains.
- **Use sand of particular value efficiently by reserving it for high quality applications and the environment.** Currently, high quality sand/substitute streams are often used for applications which do not have stringent requirements. To ensure that high quality sand/substitutes are used efficiently, they should be reserved for applications that rely on it to function, including ecosystem services (Recommendation 9). For instance, sand with a very high silica content should be reserved for industrial applications over construction applications, and marine deposits closely matching the sand along the coast should be prioritised for long-term coastal resilience.
- **Build with nature (Green vs. Grey engineering)**. Sand has key functions in nature and drives important natural processes (Box 12). NbS makes intentional use of these natural processes to strengthen engineering performance and preserve certain ecosystem services linked to sand (Recommendation 9). Replacing grey engineering with green engineering is the ‘no regrets’ option. It is natural and environmentally friendly, reduces the use of concrete, can be done in collaboration with local communities, requires low (if any) maintenance, has aesthetic value, stores carbon, supports biodiversity and usually is cost effective (Spalding et al. 2014). The NbS concept has international standing and has been adopted as a global standard by leading global organisations including the IUCN (2020b). Over the past two decades, a growing number of excellent guidelines have been developed on specific topics including those for fragile and dynamic environments (e.g., the International Guidelines on Natural and Nature-Based Features for Flood Risk Management).

### Action point 7.4 : Co-design a framework for international standards and guidelines

Sand is the most extracted material resource worldwide, yet one of the least regulated (UNEP 2019). There is a need to integrate standards, guidelines and best practices into a consistent and holistic regulatory framework that recognises sand's environmental, social and economic value. It is therefore recommended to:

1. Establish an international regulatory framework to provide a common vision and enhance the coverage of environmental issues related to sand resources, including through the formulation of guidelines and international standards.
2. Support the adoption of the said framework by member states.
3. Set out environmental priorities for international standards and guidelines on sand extraction and use.

Certain UN frameworks and initiatives already exist which can facilitate this process:

- The 2030 Agenda (UN 2015), in particular aimed at SDG 12 *Ensure sustainable consumption and production pattern* and its target 12.2 "By 2030, achieve the sustainable management and efficient use of natural resources".
- Strategy for Private Sector Engagement (UNEP/EA.4/Res.4) 'Addressing environmental challenges through sustainable business practice'.

## Box 12 : Examples of Grey Engineering vs Green Engineering

**Building walls to stabilise slopes requires high engineering and large volumes of concrete**

© G.J. Hearn

**The use of vetiver plants to stabilise slopes. Root systems of vetiver can reach up to 3 m deep. The roots hold the soil, reducing erosion and landslides. Water is absorbed by the roots and it evaporates by the canopy, removing excess water from the soil.**

© Shutterstock/Taihern

**Concrete armor unit**

© Southern Dredging and Marine

**Oyster reefs protects coastlines**

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Hybrid infrastructure (also referred to as grey-green infrastructure) makes use of ecosystems in a hybrid approach, limiting the size and/or quantity of grey infrastructures needed (Spalding et al. 2014).

# Recommendation 8 : Promote resource efficiency & circularity


## Summary

Reducing the demand for naturally occurring sand resources, substituting with viable alternatives, and recycling products, and designing products and buildings to extend their usable lifespan will be essential to keep the use of sand within sustainable limits.


## Rationale

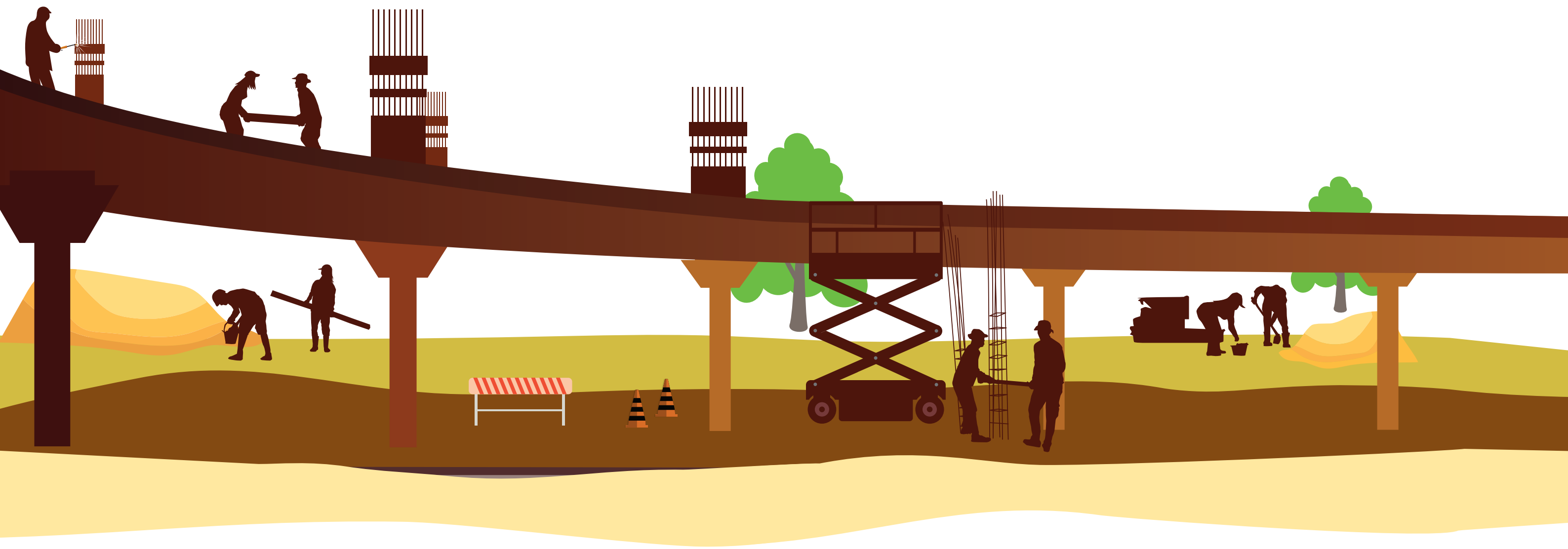
Unlike many other raw mineral materials, sand and gravel are recyclable countless times for many of its applications without a loss in quality. Moreover, there are various alternatives to naturally occurring sand.

When applied to the sand value chain, circularity could be achieved through, first and foremost, *(i) reducing the demand for sand and products derived from sand; (ii) replacing naturally occurring sand with alternative materials; (iii) reusing sand and products made of sand at the highest value possible; (iv) recycling sand and products made of sand that cannot be reused.* Combined, these are important steps in making the entire value chain more sustainable.

Sand and gravel are very broad groups of materials which are usually extracted and used locally. They are versatile, but depending on their use, can be subject to stringent requirements. The type of sand used depends on the chemical and physical characteristics needed for a certain application. In general, there are five major factors determining whether a material can be recycled and/or considered a viable alternative to naturally occurring sand and gravel:

1. Technical performance
2. Regulation
3. Environmental impact
4. Cost
5. Market proximity

Depending on the local market conditions, there are different opportunities to use policy, regulation, and good practice to help shape desired outcomes using these five key factors. Implementing resource efficiency and circularity in the sand value chain is critical to innovative sustainable infrastructure (SDG 9) and cities (SDG 11), and to ensure sustainable consumption and production (SDG 12).



## Key actions

### Action 8.1 : Reduce the net extractive demand for sand sourced from the natural environment

A combination of solutions will be required to reduce the net extractive demand for sand tied to the local context, i.e., demand for infrastructure and regional availability of alternatives

- Decouple infrastructure from material (sand) consumption and ensure better infrastructure and city planning to minimise the need for sand. Overdevelopment and dependence on housing as an investment strategy, or building massive infrastructures that are underutilised (e.g., Ciudad International Airport) are some examples of locking sand into the built environment.
- Explore NbS that can reduce the quantity used in sand-containing products (Recommendation 6).
- Design buildings so that they can be adapted, recycled, or reused without much effort to extend the lifespan of these buildings or their components. Renovating or changing the function of a building usually requires construction material but has a smaller environmental footprint than demolishing a whole building and rebuilding anew.
- Review engineering standards to avoid overdesign while still ensuring infrastructure integrity.

### Action 8.2 : Mainstream technically proven alternative materials

For a material to be a viable alternative (see Table 7 for examples) to sand and gravel derived from the natural environment, the resulting product or construct must demonstrate a strong technical performance over its lifetime. Given concerns with technical performance, alternatives to sand often struggle to be considered a viable alternative, despite meeting the technical specifications.

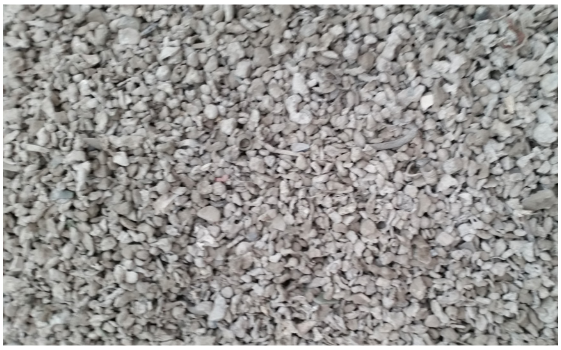
Technical standards and government guidelines, such as specifications for infrastructure works are therefore essential. These documents safeguard the quality of sand and gravel products used, setting out which materials can be used for engineering applications. For historical reasons, many of these specifications and technical standards are tailored to primary material, such as naturally occurring sand and gravel, and in certain cases crushed rock. The testing procedures referred to in these documents are also often not fit-for-purpose when applied to recycled materials, by- or co-products of other industrial or extractive processes. This effectively excludes or hampers the use of alternatives or recycled material.

In certain regions, it is still a common practice that large infrastructure projects or public works specify the material to be sourced directly from the natural environment.

Mainstreaming technically proven alternative materials can be done by:

- Listing the type and source of alternative materials, including standardised testing procedures tailored to those alternative materials or indicating special additional requirements.
- Setting-up global and national institutes that canvas and approve how various alternative materials can be used. This should include knowledge transfer on new technologies that enable the use of these new alternatives (e.g., new cementing agents), which are linked to standard institutes and insurance mechanisms.
- Putting in place a clear framework for potential alternatives to become a tested and recognised alternative material.
- Enable and encourage safe and responsible experimentation with new materials in large-scale infrastructure works, using promising alternative sources of sand and gravel in close cooperation with regulatory bodies, universities, professional organisations, and various industries.

**Table 7 : Examples of existing viable alternatives to naturally occurring sand**

| Sources of sand | Description |
|---|---|
| Crushed rock<br><br>© UNEP/GRID-Geneva/Vander Velpen | Crushed rock is a primary raw material, and it is the main alternative in the construction and industries using industrial grade sand. Although it is an alternative, it remains a primary resource that requires extraction and results in environmental impacts. Crushed rock often requires blending with naturally occurring sand. Moreover, it is also not always available where it is needed most, requiring dedicated transport infrastructure—often rail or sea—to provide the economies of scale needed to allow it to access its markets. |
| Recycled aggregates<br><br>© Gemax BV/Cuperus | Aggregates resulting from the processing of inorganic material previously used in construction (Comité Européen de Normalisation 2008). |
| Recycled materials<br><br>© Gemax BV/Cuperus | Materials originating from waste sources other than the sand and gravel value chain. The source material usually requires treatment to become fit for the intended use. Products resulting from treatment are sand, gravel or aggregates, both in varying qualities. One example is the production of aggregates from incinerator bottom ash. By classifying and removing metals, good grade material can be obtained to replace sand in road construction. Other materials include recycled ceramics, expanded slack, expanded perlites, treated dredging spoil, and cleaned excavated soil. |
| Co- and by products of industrial & extractive processes<br><br>© University of Queensland/Golev | Co- and by-products from industrial and extractive processes are a group of secondary materials, derived from the manufacturing or synthesising of another material, and could be used to replace sand and/or gravel. An example is ore-sand, a deliberate by-product from the crushing, grinding and mineral processing of different mineral ores to achieve the required properties of sand (Golev et al. 2022). Other examples include metallurgical and mineral slags. Some of the by-products need further treatment in order to meet specifications. |

## Box 13 : Construction and Demolition Waste (C&DW)

C&DW consists of more than 80% inert material, and it can be recycled as long as the hazardous and non-inert waste materials are separated from inert material during demolition. Inert C&DW is a feedstock to produce recycled aggregates.

Recycling inert C&DW is a relatively low-cost operation and it has already been implemented in cost-effective and technical performant ways, with little to no environmental impacts. Examples include the use in road construction, new concrete and asphalt production.

Usually, gate fees are requested, depending on the quality of input material and outlet options. Recycling can be encouraged by governments by imposing a ban on landfilling or, alternatively, setting high landfill taxes. It is key that dumping C&DW outside waste management facilities is prevented at all times.

Recycling does not always need to happen at a large scale. Crushing mineral C&DW can even be applied locally using simple mobile crushers. Building a network of facilities for local processing enables the availability and feasibility of crushing technology. It is key that prior to processing, hazardous materials such as asbestos and tar contaminated materials are removed, preferably before demolition. Nonetheless, C&DW not processed into recycled aggregates cannot be used responsibly for any applications as the environmental and technical quality cannot be guaranteed.

Countries with high quality C&DW recycling implement similar mechanisms to achieve this. It is possible to recycle more than 90% when the following requirements are fulfilled: 1) a ban on landfilling; 2) production of good quality recycled aggregates by the industry; and 3) the prescribed use of recycled materials, for instance in road construction. The European recycling industry published a roadmap setting out principles and actions to scale-up the recycling of C&DW (Fédération International du Recyclage 2019).

### Action 8.3 : Implement regulatory policies and cost incentives that facilitate the use of secondary materials over primary materials

In some cases, sand can be readily reused without the need for treatment (e.g., excavated/dredged sand reused on site). Several products made of sand are suitable for one or more cycles of new use without requiring further treatment before ending up in a waste stream (e.g., glass bottles, concrete products). Concrete structures that are demolished can be salvaged for new buildings. When demolition is unavoidable, make an inventory of the old concrete structure and a plan to integrate them into a new building, on site or elsewhere.

Sand and gravel derived products can usually be treated to recover sand resources which can re-enter the economy as recycled material. This is true for sand and gravel in both industrial and construction applications. Major gains can especially be made within the construction industry both in terms of resource efficiency and avoiding waste. Recycling construction and demolition waste (C&DW) is therefore primordial (Box 13).

Recycling products derived from sand and gravel, and the production of co/by-products have four important functions: (1) create substitutes for sand and gravel; (2) retain the value of sand and gravel products over multiple use cycles; (3) ensure that waste is well managed; and (4) lower the risk of environmental pollution by waste.

New incentives are needed to encourage the production and uptake of substitutes of sand and gravel. Regulation is a main instrument to initiate this. International conventions, such as the Basel and London conventions, together with waste directives, regulation, and taxation against waste generation, landfill or marine dumping/placement provide a strong starting point (Basel Convention n.d. ; International Maritime Organisation n.d.).

Recycling and replacing naturally occurring sand and gravel will be essential to solve many of the challenges in managing wastes from products derived from sand and to close the material loop. This can be achieved by implementing the following minimum requirements:

- Prevent fly tipping or the dumping of sand and gravel derived products and wastes, such as construction and demolition waste, dredging spoil or glass.
- Ban landfilling, or put a significant cost on landfilling of mineral waste, and in the case of the dredging industry, marine dumping/placement.
- Better plan selective demolition and deconstruction (in the case of demolition waste).
- Encourage the reuse of sand and gravel where possible by prescribing this practice into public works and procurement.
- Encourage reuse and/or the uptake of recycled aggregates, by-products, and coproducts and of recycled sand and gravel, for instance by prescribing them in green public procurement and public works.
- Encourage industry to invest in recycling facilities close to the source of waste.

## Box 14 : Case-study - Recycling of construction and demolition waste in Mexico City

In Latin America, awareness is rising that C&DW should be well-managed. Mexico City is a frontrunner in this development. Official data shows that around 30,000 tonnes of C&DW (including excavated soil) are generated daily in Mexico's metropolitan area. This large volume used to find its way to both regulated (landfills) and unregulated applications (rivers, dams, natural protected areas - illegal dumping). Significant environmental damage to the ecosystem was a main driver in Mexico City's changing C&DW policy. Another driver was the strong business case for recycling. An initiative to build a recycling facility closer to the places where waste is generated reduced transport distance by 80%. Although gate fees are higher than landfill fees, recycling is now the preferred option. The first recycling facility processes up to 250 tons C&DW per hour, with another recycling plant running on pure inert C&DW. Seven other recycling plants are planned for construction in Mexico.

This high recycling rate in Mexico City is made possible by new legislation, which requires contractors to have a contract with a recycling facility discarding the waste adequately. Mexico City's recycled product market is further stimulated by the requirement for constructors to show proof (a legal invoice) that recycled materials are used in their construction works. These recycled materials include recycled aggregates, pre-mixed concrete based on recycled material and asphalt produced with reclaimed asphalt (Asociación Mexicana de Reciclaje de Residuos de Construcción y Demolición S.C n.d.).

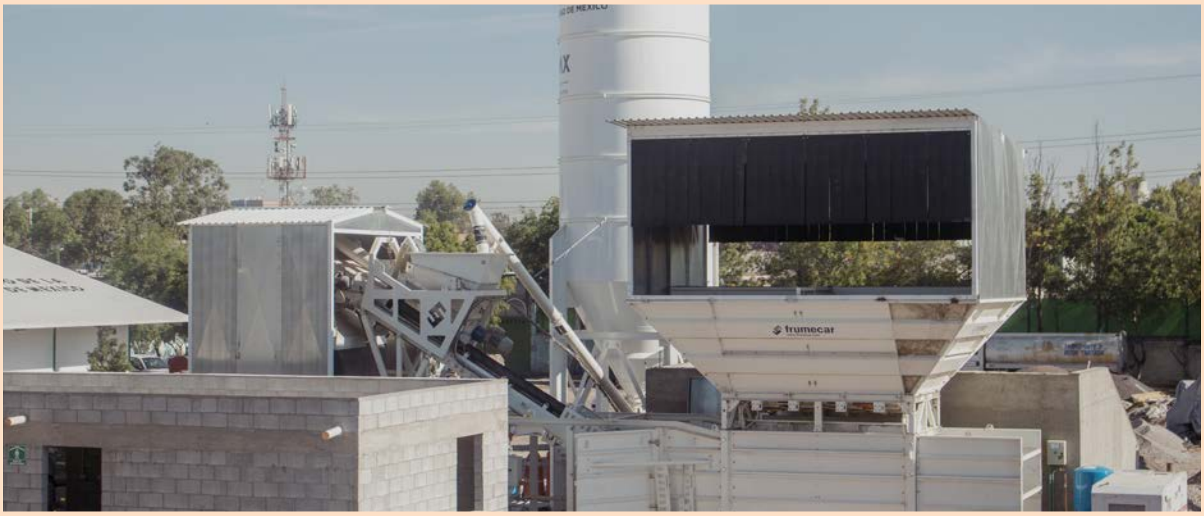
**Centro Integral de Reciclaje Miguel Hidalgo, México.**

© Asociación Mexicana de Reciclaje de Residuos de Construcción y Demolición S.C

**C&DW processing belt at a recycling plant, México.**

© Asociación Mexicana de Reciclaje de Residuos de Construcción y Demolición S.C

**Recycling plant, México.**



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### Action 8.4 : Put in place a robust regulatory framework and testing procedures to provide environmental guarantees

Environmental, health and safety risks in using alternative sources for sand and gravel, are often an important concern. Providing sufficient environmental guarantees, trusted by public authorities and the general public, that both the alternative material and the procedure through which it is produced, are environmentally sound and do not pose health or safety risks are major challenges to overcome.

Public authorities should help producers of alternative sand resources by putting in place a robust regulatory framework and testing procedures which:

- Evaluate the environmental risk from leaching and dispersion. The immediate risk can vary considerably depending on whether the sand or an alternative is processed further (e.g., melting glass), whether it is used as a loose material or enclosed in membrane/matrix/bitumen, and the environmental conditions where it is used.
- Evaluate the presence of hazardous elements.
- Minimise the use of materials which impede the recycling of a given product. The use of certain alternative materials complicates the recycling and/or might set free pollutants. This may be the case for trace metals that may leach. A negative example of using waste materials is when plastics are used in applications such as road construction, which can significantly increase the risk of spreading microplastics. Mixing in plastics also prevents the recycling of the material.

### Action 8.5 : Consider sustainability factors and externalities costs of not using alternative materials in sand procurement

Primary sand and gravel are often cheaper to purchase than alternatives such as recycled sand and co- and by-products. However, extracting primary materials, instead of using recycled materials and co- or by-products, usually comes with an environmental cost. This avoided environmental cost is often not reflected in the alternative material's purchase price, making it less competitive. However, in densely populated areas, transport costs from more remote primary resources outweigh the cost of recycling local sand and gravel materials, reflecting the gradual change in cost consideration.

Governments can incentivise the use of alternatives for sand through implementing sustainable public procurement (UNEP 2021b). Governments should consider end-of-life and externality costing, giving more weight to sustainability factors and performance-based criteria when awarding contracts, rather than basing procurement decisions on the lowest-cost bid (ibid.).

## Box 15 : Case study - Introducing ore-sand as an alternative aggregate at scale

Awareness of sand sustainability is generating clear calls for alternatives at scale. Among secondary sources, one stands out globally – mineral ores. Currently large volumes of sand- and aggregate-like materials are produced by crushing mineral ores for the extraction of metals (and other commodities), which are then discarded as part of mine waste rock and tailings (Golev et al. 2022). The global mining industry thereby generates billions of tonnes of waste that could potentially be recovered every year (Franks et al. 2021).

Attempts to give mining residues a second life have been made in the past, and suitability for certain applications has been proven. However, serious uptake has been impeded because : 1) these residues must be technically and economically competitive with conventional materials and 2) they were residues, rather than by-products or co-products that required their own optimisation to achieve specific properties during mineral processing (Golev et al. 2022). Thus, a step-change in mineral processing towards alternative aggregate recovery could help the world address the sustainability challenges of both mine tailings production and sand extraction.

**Ore-sand** is a type of processed sand sourced as a co-product and/or by-product of mineral ores. Typically, it is a result of mechanical crushing and grinding, different physical and physicochemical beneficiation processes for mineral concentrates recovery, including optimisation of these processes and additional processing stages to achieve the required properties (ibid.). Importantly, ore-sand is a deliberate product produced by design, rather than repurposing of existing waste materials. Given that certain ore bodies are associated with minerals and potentially harmful and hard to remove trace elements, a thorough evaluation of the mineral ores is required to guarantee the production of ore-sand which is safe to use.

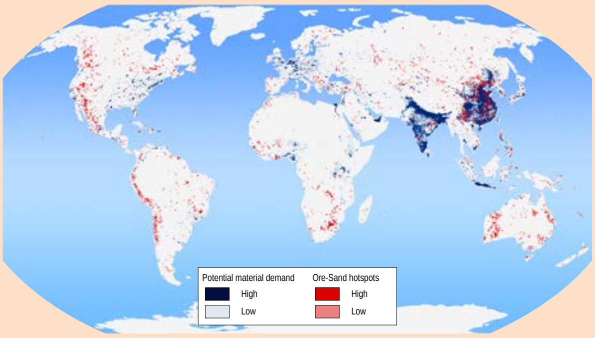
An example of one of the first dedicated ore-sand recovery projects at scale is Vale Sand. Vale is a Brazilian multinational corporation and one of the world's largest producers of iron ore. In 2013, Vale initiated the Quartz Project to investigate whether sand by-products could drastically reduce the amount of tailings requiring storage at its mine sites (Vale S.A. 2016). After two high profile tailings storage facility failures, Vale accelerated the innovation and development of ore-sand in its motivation to find an alternative waste management solution. In 2021, Vale received its first environmental licence for sand by-product, and launched several large-scale initiatives for the reuse of ore-sand for road construction, concreting, and bricks manufacturing (Vale S.A. 2020).

The University of Queensland's Sustainable Minerals Institute (SMI) and University of Geneva (UNIGE) are undertaking research on ore-sand, using Vale Sand as a case study (Golev et al. 2022). The properties of ore-sand vary depending on the type of mineral ore and the processing. The results of the study have demonstrated that ore-sand from iron ore is typically a fine sand, with low trace element content, which has the potential to offset sand demand by blending with naturally occurring sands. In scaling such alternative aggregates, relative economic and technical advantages, approval from regional and natural regulatory bodies, partnerships with customers supporting demonstration of the material and a sustainability agenda are essential. The minerals sector, construction industry, and policy makers will need to continue to work closely to investigate the potential opportunities and barriers for adopting alternative aggregates, such as ore-sand, at scale.

**Ore sand stockpile and transportation, Vale's Brucutu mine, Brazil.**



**Map 2 : A map showing mining locations (red) and areas where there is a significant demand for construction sand (blue).**




Source: Adapted from (Golev et al. 2022)

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# Recommendation 9 : Source responsibly


## Summary

Responsible sourcing is an approach through which an organisation actively and consciously sources and procures products and services for their operations in an ethical, sustainable, and socially conscious way. Supply cha-in responsibility works as an incentive for economic actors to not only adjust their own production process to the highest social and environmental standards, but to consider where the material they use comes from and what happens to their product afterwards. Although the sectors using sand resources can be diverse, the supply chain's structure provides a number of opportunities for the responsible production and consumption of sand to be more accountable:

1. Ensuring that sand resources purchased are extracted and transported in a socially and environmentally sound manner and that it is the right quality for the application (Responsible Sourcing).
2. Ensuring that the production process is up to the best possible environmental and social standards, including the raw materials it uses (Responsible Production).
3. Ensuring the product is designed in a way it can be properly re-used, repaired, or recycled at end-of-life and that there is a system in place to treat it with the highest resource efficiency and the lowest carbon footprint possible (Responsible End-of-life).


## Rationale

The supply chain needed to provide society with the required volumes of sand resources in a sustainable way is often not properly considered in planning and decision making, and this is particularly true for infrastructure, construction, and marine works. In general, the sand resources supply chain for construction and infrastructure is structured as follows:

*Project funders – The entities that are ultimately funding and supporting the supply chain. The funds they provide to deliver projects pay for the mineral products and the sand resources. While some funding will be derived from private investment, a significant amount of funding for construction activity comes from public investment, ultimately funded by a government.*

*Client – The entity who is responsible for contracting the delivery of a project using funds that have been provided. In some cases, the client may also be the funder, such as a project is being directly funded and delivered by a government. The client may be a public body, or a private commercial interest.*

*Contractors/material specifiers – Commercial entities who have been appointed by the client to deliver construction projects, and in doing so responsible for procuring the sand resources and/or mineral products to support their delivery. Very often this will involve various layers of primary contractors and subcontractors.*

*Mineral product manufacturers – Commercial entities who purchase the sand resources to make added-value products, such as ready-mix concrete and concrete products (but may also include glass, asphalt etc.), which are then procured by contractors or their sub-contractors.*

*Mineral resource producers – Those responsible for extracting sand resources so they can be sold. Some interests may be commercial entities, while others may be more artisanal producers.*

Despite the strategic importance of a sustainable supply chain, the responsibility tends to be pushed down the chain, thus reducing accountability. Sustainable production and sourcing are unlikely to happen where there is no benefit or advantage to those responsible for extraction or manufacturing to demonstrate sustainable practices. Likewise, if there are no legal or commercial consequences to punish irresponsible and unsustainable practices, it will be difficult to hold actors along the supply chain accountable.

However, at every stage of the supply chain, there are different opportunities to use policy, regulation, and good practice to shape desired outcomes. Although there are few legislative mechanisms that require the use of sustainable supply chains, there is a growing number of management frameworks that allow the supply chain for construction materials, including sand resources and concrete, to be assessed, audited, and certified to demonstrate responsible sourcing practices (Box 16). Responsible sourcing supports sustainable consumption and production (SDG 12), specifically Taraget 12.2 "By 2030, achieve the sustainable management and efficient use of natural resources", and promote inclusive and sustainable industrialisation (SDG 9).

## Box 16 : Case study - Responsible Sourcing Frameworks

The concept of responsible sourcing is already well-established for other natural resources and products, most notably fair-trade food. In addition, frameworks are also available to support the procurement of construction materials.

Responsible sourcing frameworks can be required by the funder or contractor delivering a construction project, in order to influence expectations and behaviours in procuring the raw materials and associated products required through the supply chain. By defining standards and expectations, any party looking to supply a project is required to provide evidence of the source of the materials. This includes not only the products themselves—such as ready-mix concrete or concrete products—but also the raw materials used to produce them. Conversely, those producing construction products may choose to adopt responsible sourcing frameworks to provide reassurance to those procuring their products. The principal driver of these frameworks is to improve the transparency of the sustainability credentials throughout the concrete supply chain, allowing materials to be recognised in "green" procurement policies and building rating systems.

- One example is the BES 6001 developed by BRE Global (BRE Global 2016), an independent international certification body, which defines a Framework Standard for the Responsible Sourcing of Construction Products. This framework provides manufacturers and distributors with a process through which construction products can be independently assessed and certified as being responsibly sourced. In order to achieve this, the Framework Standard defines a series of compulsory requirements that companies, or those in their supply chain, need to meet to demonstrate their products are being sourced responsibly. These include organisational management (environmental, quality and health and safety working practices), supply chain management (material traceability & health and safety), environmental impact (including GHG emissions, water use, transport) and social requirements (employment and skills and local communities).
- An alternative approach has been developed by the Concrete Sustainability Council (n.d.), whereby concrete industry partners from Europe, USA, Latin America, and Asia have developed their own global responsible sourcing certification system. The independent certification process includes the whole concrete supply chain : cement producers, aggregates suppliers and concrete manufacturers and requires consideration of ethical and legal compliance, human rights, indigenous people rights, environmental and social impact, and traced materials. The system is designed to help concrete, cement and aggregate companies demonstrate they are minimising impacts and operating in an environmentally, socially, and economically responsible way.

While predominantly developed to meet the needs of "green" procurement, the principles and mechanisms provided by these frameworks could be applied to any development situation where greater transparency is required around the responsible sourcing credentials of all aggregate resources (including sand) and the value-added products produced from them.

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## Key actions

### Action 9.1 : Instruct funders of major infrastructure projects to recognise their role in responsible sourcing

- Funders of major infrastructure projects have a powerful opportunity to influence outcomes and drive behaviours in the production, supply, and consumption of sand resources – particularly through the use of responsible sourcing frameworks. Major infrastructure projects are generally funded through:
    - Public investment, where the government invests directly in the infrastructure that supports its economy ; or
    - External investment by organisations that fund growth and development such as the World Bank, Sovereign Wealth Funds, or other forms of global investment – Hedge Funds, Pension Funds or loans and grants from other governments. In both cases, major projects will need to be supported and permitted by the national administrations.

As sand should be considered a strategic resource (Recommendation 1), strategic planning is essential to ensure the right sand resources are available in the right place and at the right time to support outcomes that are both cost effective and sustainable (Recommendation 5). But to do this, greater visibility is required about the sand resource needs that are necessary to deliver the desired outcomes (see also Action 10.4, 3.2 and 3.4).

### Action 9.2 : Adopt a responsible sourcing framework

- Responsible sourcing frameworks provide a means to address the sourcing of sustainable sand resources from the top of the supply chain, with project funders and/or clients defining requirements that can cascade through the supply chain.

Although sand represents a strategic development resource, the availability and supply of the construction materials that will be required to realise construction projects will often be assumed by those who fund them. As a consequence, the sand resources and concrete products used may end up being the cheapest but are unlikely to be the most sustainable because supply will be reactive rather than properly planned.

In order to measure the environmental impact of construction activity, the industry has to start including indicators that go beyond the immediate impacts at the site of construction, taking into account the full supply chain of the materials used. The responsibility for sourcing the sand resources used in the construction sector is generally passed down to the mineral resource producers and/or manufacturers.

It can be easy to focus attention on those parties who are responsible for extracting sand resources, as in many cases this is where the direct social, economic and environmental consequences arising from the removal of a finite geological resource can arise – particularly if the activity is not subject to sufficient regulation or management. However, it is important to recognise that the production of these raw materials represents only the very first step in a much larger supply and value chain for construction activity, which in turn is related to economic growth.

### Action 9.3 : Require 'construction material resource and supply chain plans' for all new major infrastructure projects

- Construction material resource and supply chain plans can provide greater transparency and scrutiny of the sand resources needed and by proactive planning for the necessary resources' sustainability criteria can be taken into consideration.

Across both developed and emerging economies, the availability of sand resources to support the sustainable delivery of major infrastructure projects is largely assumed. The preparation of construction material resource and supply chain plans as an integral part of the funding and permitting of major infrastructure and construction projects would allow greater understanding of the raw materials needed to deliver them, and where these resources can be sourced from to ensure the most sustainable and cost-effective solutions. In turn, this would help to ensure greater transparency around the wider supply chain that is integral to the successful delivery of projects, particularly if such reports are independently reviewed and audited. This approach would help drive more sustainable behaviours throughout the supply chain that supports major projects, and which ultimately is responsible for consuming the largest volumes of raw material.

Alongside the source and quantities of raw materials required, the construction material resource and supply chain plan provide an opportunity for greater scrutiny and guidance around how resources are being used. For example, are secondary and recycled materials available and being used to minimise the requirement to use new sand resources? If new sand resources are being used, are high quality resources only being used where they are necessary? Such an approach would also allow greater oversight of the efficiency with which resources are being consumed.

### Action 9.4 : Implement the principle of supply chain accountability

- The responsibility and accountability for ensuring the sand resources supporting construction and infrastructure projects come from appropriate sources needs to be clearly defined.

Too often, the responsibility for doing this will be devolved to contractors, who then pass the responsibility on to sub-contractors, who in turn pass it on to suppliers. This results in the transparency and accountability for responsible sourcing becoming lost through the supply chain. To avoid this, the funders of major projects should be instructed to define clear ownership and accountability for responsible sourcing, with audit mechanisms in place to track performance throughout every level of the supply chain. One example is the EU's push to enshrine mandatory due diligence and sustainability reporting on supply chains into binding legislation through its Corporate Sustainability Reporting Directive (European Commission 2021b).

### Action 9.5 : Encourage companies to sign-up to the United Nations Global Compact

- Having a large national business community signed up to the United Nations Global Compact is a clear expression of commitment to positive change and enables the participation in international dialogue.

The United Nations Global Compact, the world's largest corporate sustainability initiative, defines supply chain responsibility as operating in ways that, at a minimum, meets fundamental responsibilities in the areas of human rights, labour, environment, and anti-corruption, throughout the life cycles of goods and services (UN Global Compact n.d.). The Global Compact sets out the ten principles towards which businesses should align, taking action to support broader goals of the SDGs.

# Recommendation 10 : Restore ecosystems and compensate remaining losses


## Summary

Ensure the restoration of degraded ecosystems where sand mining activities have either directly or indirectly contributed to the degradation, implement compensation mechanisms for remaining losses, and promote nature-based solutions for the restoration of affected rivers, coastal, and land systems.


## Rationale

The extraction of natural resources from land, freshwater, and marine areas comes at a price to the natural systems that communities depend on. Sand and overall aggregate mining practices need to incorporate actions to avoid, minimise, restore, and compensate ecological and socioeconomic impacts (mitigation hierarchy), and can even contribute to a net gain in ecosystem services and biodiversity when possible. In addition, sand resources can contribute to restoring and protecting land, freshwater systems or coastal areas from erosion or flooding through NbS, whilst preserving the integrity of the land-sea continuum. Removing obstacles for the implementation of compensation mechanisms and monitoring and reporting systems will be key in ensuring successful outcomes.

In June 2021, the UN launched the Decade for Ecosystem Restoration 2021-2030 to prevent, halt, and reverse the degradation of ecosystems worldwide, contributing to reduce poverty (SDG 1), combat climate change (SDG 13) and prevent a mass extinction of biodiversity (SDG 14 and 15). The extraction of natural resources from land, freshwater, and marine areas comes at a price to the natural systems on which communities depend (Recommendation 1 and 2). Often, the impacts of mining are complex, indirect, and far outside the boundaries of the extraction site for decades into the future, especially when mining projects target sands that play an active role in dynamic ecosystems. Broader human activities during the latest centuries, such as the construction of dams and urban growth, have contributed to undermine the resilience of river and coastal systems starved of sand, whose situation will only accentuate with climate change (Recommendation 1 and 6).

Preserving natural ecosystems is much less costly than restoring and replacing them. Ignoring the large-scale and long-term consequences of mining activities, and how their impacts cumulate with other stressors, comes at a high cost, resulting in expensive and lengthy restoration interventions that rarely lead to a complete recovery (Jones et al. 2018). Such is the case of the restoration of the Mississippi delta, one of the most expensive restoration programs in the world requiring more than US$50 billions of government grants, and a significant drag to Louisiana's economy (Coastal Protection and Restoration Authority of Louisiana 2017).

Transitioning towards a circular economy requires reducing the dependence of natural systems (Recommendation 8). When extraction is deemed necessary, sand resources must be obtained in a sustainable manner in which damage to ecosystems and people is prevented and/or minimised. Thus, actions need to be taken to avoid and minimise future impacts, restore, and compensate for past, ongoing, and predicted damages on biodiversity and ecosystem services, and invest in NbS for addressing water security challenges, flooding risks and climate adaptation.

## Key actions

Four core actions look most promising to meet restoration and compensation goals.

### Action 10.1 : Advance and apply the latest knowledge on impact assessment, mitigation, and compensation

- Enhance the use of science-based evaluation and monitoring as the basis for impact assessment, planning for mitigation, and compensation.
- Encourage the public reporting of mitigation and monitoring outcomes according to FAIR principles.
- Empower local actors, organisations, and authorities to access and apply the latest available information to inform their decision-making.

Planning and regulatory tools should require that the most up-to-date scientific knowledge informs impact and ecosystem assessments, leading to the design of effective prevention, mitigation and compensation measures, and monitoring plans. Assessments must capture the full extent of mining-related impacts on ecosystems, including impacts beyond mining sites (e.g., erosion downstream, groundwater pollution) and indirect impacts (e.g., changing habitat distribution, increased traffic disturbances). Conscious efforts should be undertaken to improve the knowledge-base and address the remaining gaps around the mining impacts on biodiversity (Torres et al. 2022a) and ecosystem services, and the effectiveness of mitigation and restoration efforts (Hunter et al. 2021 ; zu Ermgassen et al. 2019). This requires ample funding for research activities; collaboration across industry, government and research institutes; and incentives to encourage mining operators to generate scientific data through site-based research.

Monitoring systems should be put in place to evaluate whether mitigation measures, and compensation mechanisms are achieving the target goals. Monitoring must extend for a sufficient period of at least 10 years to assess the effects of compensatory mechanisms (Levrel et al. 2012), although this strongly depends on the scale of the affected system. Monitoring plans should account for the cumulative effects of existing and known future stressors acting on the system.

Both mitigation measures and monitoring outcomes should be routinely publicly reported, enabling the continual improvement of the evidence base behind mitigation[35]. Data should be reported according to FAIR and open practices. National authorities need to ensure that local institutions and organisations are empowered to access, apply, and contribute to the latest available information to make knowledge-based decisions (see Recommendation 2 and Action 1.1).

### Action 10.2 : Mainstream the mitigation hierarchy for sand mining projects

The mitigation hierarchy framework (Figure 6) is a well-established tool for making explicit decisions balancing conservation needs with development priorities (Borges et al. 2014). Following this framework, government regulators should:

- Ensure that sand and aggregate mining projects fully consider the risks to biodiversity and ecosystem services through four stages of mitigation: avoidance, minimisation of impacts, restoration, and offsetting.

    a. **Avoidance** measures involve preventing impacts in the planning and design phase of the project, for example by relocating project components, modifying the timing of activities, and modifying the design to avoid or reduce impacts. Non-offset-able impacts to threatened or poorly understood ecosystems and species (i.e., irreplaceable assets), and not acceptable social impacts must be avoided.

    b. At the **minimisation** phase, measures are taken to reduce the duration, intensity and/or the extent of impacts that cannot be avoided. Where possible, thresholds of extraction should be formulated.

    c. **Restoration** involves implementing measures to restore ecosystem functions and complexity following exposure to impacts. Approaches to restoration can be passive, i.e., letting the ecosystem to self-recover, or active through physical interventions to allow the ecosystem to recover in its integrity and the natural processes that underpin it (e.g., environmental engineering).

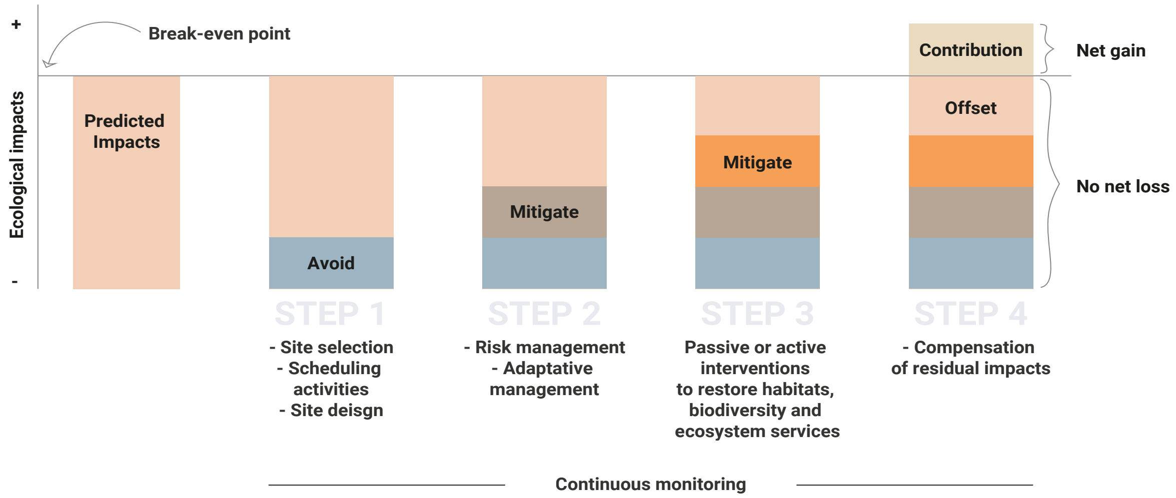
    d. Any significant residual impacts that may remain are offset. **Offsetting** involves compensating for impacts on biodiversity that are unavoidable and cannot be addressed through minimisation or restoration to achieve no net loss or net gain.

Policies and legal instruments that aim at ensuring no net loss/net gain of biodiversity and ecosystem services are increasingly influential, but often lack clear reference scenarios and carry the risk of misuse (Maron et al. 2018). To reduce that risk and strengthen nature positive outcomes, it is important that government regulators:

- Require that alternatives are considered and assessed, and that mitigation and offsets are designed and implemented with clearly specified baselines, reference year, goals, and measurable targets (Maron et al. 2021). To minimise trade-offs between outcomes for biodiversity and ecosystem services, offsets must consider both, and be designed and implemented

35 For example, published in the Conservation Evidence database, or shared through knowledge networks like (ECOSHAPE n.d.) and (SedNet n.d.).

**Figure 6: Mitigation Hierarchy**

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following a comprehensive assessment of losses and gains that arise from the development and offsetting plans (Sonter et al. 2020).

In addition, actions need to consider that:

- Investments in impact assessment and restoration must be on the scale of volumes extracted and of the sensitivity of the ecosystem in the influence zone of the extraction activities.
- Impacts of mining on species and ecosystems and restoration efforts must be placed thoughtfully within their wider environmental and socioeconomic context and weighted thoroughly against alternative pathways to sand mining.

Regulatory tools should require sand and aggregate operators to assess the importance of biodiversity and ecosystem services at proposed mining sites, and their potential risks for surrounding ecosystems and human communities, and mandate management responses proportionate to their importance. The higher the risk, the more stringent the response must be robust baseline studies should therefore be an integral part of planning and permitting requirements of sand and aggregate mining projects and inform the development of management measures for the inception, operation, and closure of quarries.

### Action 10.3 : Promote Nature-based Solutions to ensure an integrated landscape approach in ecosystem restoration

- Assess natural processes in the area of interest and maximise these processes to accomplish restoration goals.
- Use secondary resources, such as dredged sediment or clay, to reduce the need for naturally occurring sand through NbS and its ensuing “building-with-nature applications”.
- Identify and amplify opportunities to enhance the benefits of mining and restoration projects for biodiversity and ecosystem services.

The concept of NbS conveys the idea that it is often more effective to work with nature rather than against it. Natural processes and sand resources can be used as an ally in addressing challenges such as land subsidence, coastal erosion, flooding, and impacts from natural disasters, improving the livelihood of local communities. This approach considers the broader natural and social systems of a given project and engages relevant stakeholders from early stages to maximise positive outcomes.

Key for the success of these initiatives is the selection of the right type and source of sand, which should be as similar as possible to the original ecosystem and from a location that ensures that the sand stays in the system and minimises the risks of problem shifts. In many innovative applications, other dredged material, such as mud, have been used in building-with-nature solutions, decreasing the need for sand[36].

In mining projects, the opportunities to enhance the provision of benefits for biodiversity and ecosystem services once in operation or abandoned must be identified and maximised. Many pits and quarries occur in areas where previous human action has caused extensive loss and degradation of habitats such as wetlands, natural grasslands, steppes, dunes, or riverbanks, among many others, resulting in highly homogenous landscapes often dominated by intensive agriculture and forestry. With careful management and monitoring, active and restored sand pits or quarries can contribute to create

36 E.g., Markerwadden project (Natuur Monumenten n.d.)

## Box 17 : Case studies - Delivering benefits for nature and people

Although the goal of mining projects is delivering raw materials, there are significant opportunities to maximise the provision of benefits for biodiversity and ecosystem services once the mine is in operation or abandoned. In the UK, quarry restoration makes a significant contribution to long-term nature recovery and conservation (MPA 2021). By 2020, the UK's minerals sector created over 83 km² of priority habitat supporting nature recovery, with a further 110 km² pledged in approved restoration plans. Today, more than 80 restored quarries make up a 'National Nature Park' coordinated by the sector's trade association, the MPA, and it is considered of special interest to nature conservationists and civil society. Although biodiversity features prominently in most schemes, restoration is also about making appropriate use of land with some sites being restored back to agricultural use, or for recreation, or for new development – including housing, commercial and leisure uses. In all cases, the successes of quarry restoration are made possible through constructive partnerships among mineral producers, local authorities, conservation organisations, and others.

Another example of successful partnership is the pioneer rewilding area of Millingerwaard (600 ha) located in the uppermost section of the Rhine Delta (Jepson et al. 2018). In the early 1990s, the area was dominated by intensive agriculture and hydraulic engineering and was poor in biodiversity. Then a rewilding project started to promote the ecological restoration of the riverine landscape. Through this process the spontaneous development of natural, wooded vegetation and sand dunes reduces the free flow of water and may increase flooding in the long-term. To mitigate the flood risk to adjacent inhabited areas, sand is extracted in some floodplains by excavating old river channels. Moreover, sand and clay mining has contributed to finance restoration initiatives, including the purchasing of agricultural land and species reintroductions. A continuous interaction between the Dutch State Forest Service, the mining company and conservation organisations to design sand and clay mining activities with the Living Rivers philosophy has contributed to the reshaping of the floodplain, making it wilder and more attractive to visitors.

A final example is the Spanjaards Duin dune (van der Meulen et al. 2015) area in the Netherlands, home to an ongoing compensation project related to the Port of Rotterdam's expansion. Construction work was predicted to increase traffic emissions, resulting in increased atmospheric nitrogen deposition, which would damage rare and threatened natural dune habitats. As compensation measure, an area of 40 ha of artificial dunes was created in front of the existing dunes of the Delfland coast along the North Sea. The project started with 6 million m³ of beach and dune nourishment. Then, natural processes such as wind action, rainfall, groundwater dynamics, and spontaneous vegetation growth followed to shape the area into natural dune habitats. An extensive monitoring program informs decision-makers if interventions are needed and allows for an adaptive management approach. The compensation habitats should be completely established by 2033.

**Restoration at Titterstone Clee Hill in Shropshire (UK)**

© Mineral Products Association

**Ouse Fen Nature Reserve in Cambridgeshire (UK)**

© Hanson UK/RSPB

**Millingerwaard rewilding project in (the Netherlands)**

© Rijkswaterstaat (only for non-commercial use)

**Spanjaards Duin dune area (the Netherlands)**

© Deltares/Stéphanie IJff

valuable habitats that can attract rare, restricted, or threatened species (see Box 17). These opportunities are nevertheless context and site-dependent, varying with climatic, ecological, and socio-economic factors, and actions must vary accordingly (Salgueiro et al. 2020).

### Action 10.4 : Facilitate the adoption and enforcement of compensation mechanisms

Through compensation schemes, the losses and future costs of sand and aggregate mining activities are compensated and repaired.

- Identify implementation obstacles (e.g., insufficient knowledge of impacts, availability of monitoring systems, or policy and legal barriers) and actions to address them.
- Include the environmental impacts of sand and aggregate mining within the scope of finance environmental safeguard policies, so as to integrate the costs of mining activities in urban and infrastructure projects' financing.
- Ensure that the funds obtained through compensation mechanisms are directed towards environmental and social improvements.

The adoption of compensation mechanisms remains limited in the sand and aggregates industry. Compensation schemes can be implemented via direct negotiation/amicable resolution, policy incentives, legal procedure, the introduction of taxes can generate revenues for the restoration and compensation of environmental and social damages (e.g., Makueni County Sand Conservation and Utilization Authority in Kenya, see Box 8), adapting the concept of benefit sharing, or zoning regulations in space and time.

An opportunity to internalise the costs of mining activities is to account for supply-chain impacts of sand resources when financing urban and infrastructure development projects (Recommendation 8). At present, major multilateral development banks' environmental safeguard policies hold their clients responsible for some supply-chain impacts of the projects they help finance, but often non-living raw materials such as sand are excluded (e.g., the International Finance Corporation, Asian Development Bank) or their consideration remains ambiguous (e.g., the Equator Principles (The Equator Principles Association 2022)). A wording change to adopt the definition of raw materials used in the World Bank safeguards (which includes sand and gravel) would lay the groundwork for internalising the supply-chain impacts of construction mineral consumption into tens of billions of dollars' worth of project financing each year (Torres et al. 2022b) which should significantly increase the budget invested in impact minimisation and restoration.

To ensure the implementation of compensation schemes agreed are honoured in practice, mechanisms should be put in place to assign the relevant funds directly towards the agreed environmental and social improvements. A good example is the "Marine Aggregate Levy Sustainability Fund" introduced by the UK government in 2002 to secure funds to monitor, investigate, and address the environmental impacts of marine aggregate extraction (Söderholm 2011) (see Action 8.1, Action 10.2, and Action 10.4).

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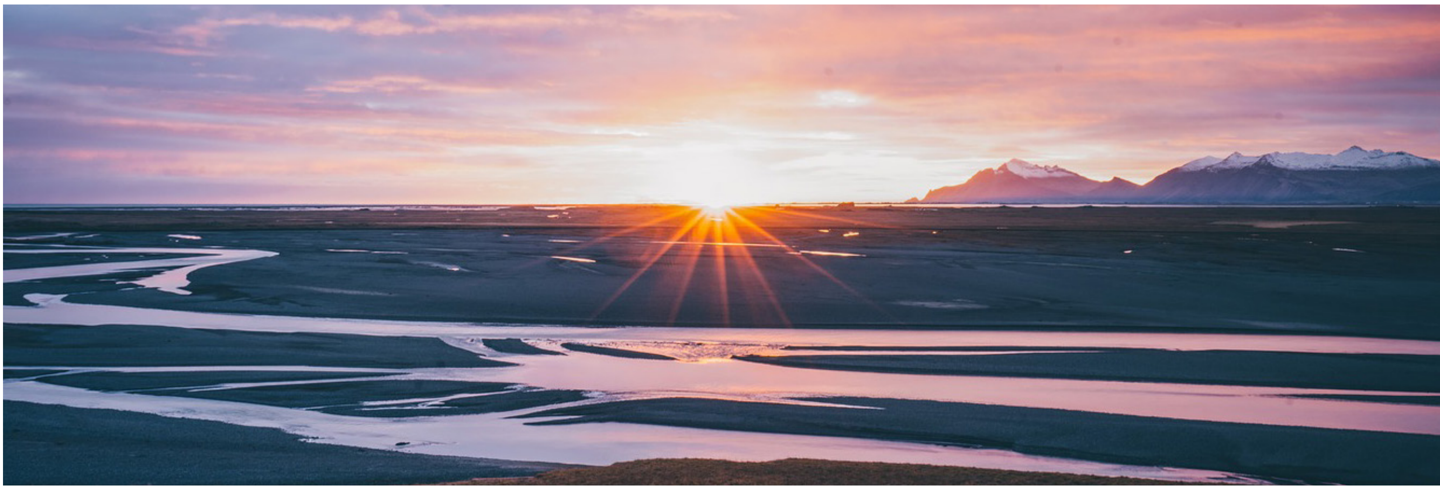


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# Conclusion

## To make sand resource management just, sustainable, and responsible

Recognise sand as a strategic resource

Include place-based perspectives for just sand transitions

Enable a paradigm shift to a regenerative & circular future

Integrate policy & legal frameworks

Create a mineral ownership and access framework

Map, monitor and report sand resources

Establish best practices, national standards, & a coherent international framework

Promote resource efficiency & work towards circularity

Source responsibly

Restore ecosystems degraded by sand mining activities & compensate remaining losses

# Conclusion

Despite the recent media interest and actions taken by international organisations, the sand and sustainability challenge remains off the radar for governments, financial institutions, the construction sector, and other key stakeholders.

All this while, sand has become a strategic resource: a vital resource for economic development as well as a key component to climate resilience and ecosystems. It is intricately linked to the 17 SDGs, either because sand is needed to achieve the SDGs, or because its extraction might impede efforts to a more sustainable future. Demand for sand will increase with population growth, rural-to-urban migration, a growing need for infrastructure that is tied to development, not to mention climate change adaptation efforts. Our dependency on sand resources is staggering. Thus, the responsible and just governance and management of sand will be imperative to our ability to achieve the Global Goals by 2030.

This report has illustrated the cost of sand extraction in both static (e.g., terrestrial sand pits) and dynamic (i.e., rivers, marine and coastal) systems, where sand plays critical roles. In several places, the lack of governance on sand resources is creating complications on the ground, such as illegal sand mining that has been, in some circumstances, associated with violence. Communities grappling with depleting resources are also more likely to face the environmental consequences of floods, reduced water availability, biodiversity loss, and socio-economic impacts including loss of livelihoods.

If sand extraction is not carefully managed, it can lead to significant environmental and societal impacts, hampering future developments, as well as generating more costs than benefits (**Recommendation 1**). A transformation in our governance and management of sand resources is therefore necessary to avert a crisis. This transformation must address environmental sustainability alongside justice, equity, technical, economic, and political considerations. It is critical that as a global community, the strides we make towards sustainable development is inclusive and just for all (**Recommendation 2**). Simultaneously, breaking down silos between sectors and embracing diverse materials and models are critical for the shift towards a regenerative and circular economy (**Recommendation 3**).

To make sand resource management just, sustainable, and responsible, we therefore need to:

1. Set-up the institutional structures governing sand resources, which:
    a. Integrate policy and legal frameworks (**Recommendation 4**)
    b. Create an effective mineral ownership and access framework (**Recommendation 5**)
2. Set-up and implement tools and instruments, including:
    a. Map, monitor and report sand resources for transparent, science-based, and data-driven decision-making (**Recommendation 6**)
    b. Establish best practices, national standards, and a coherent international framework (**Recommendation 7**)
    c. Promote resource efficiency and work towards circularity (**Recommendation 8**)
    d. Source responsibly using the principle of supply chain responsibility (**Recommendation 9**)
    e. Restore ecosystems degraded by sand mining activities and compensate for remaining losses (**Recommendation 10**)

## Implementation Realities

These 10 recommendations are not exhaustive, but they pave the ways in which we should rethink our relationship with sand. However, some immediate questions remain when implementing these recommendations, including the availability of the human, financial and technical resources required. Meanwhile, changing the status quo of sand resource governance will change outcomes for some individuals and organisations, for better or worse; it is a reality that needs to be well understood.

Regardless of the challenges ahead, these recommendations are key to responsible sand governance and management, while recognising that actions taken should be feasible, effective and suitable with the local context and resources available. Acting on these recommendations, though not without its challenges, is likely to offer the much sought-after synergies within sustainable development- between minerals regulation and land use planning; demand drivers and the scaling up of alternative materials; and just transitions in environmental management and poverty reduction. Introducing new processes might very well generate new business opportunities, including those from recycling construction materials and the innovation known as ore-sand.

## Humanity at a crossroads : The need for systems level change

The planet is fast approaching, perhaps even exceeding, the Earth System's limits, which risks shifting the equilibrium away from a 'safe operating space' (Rockstöm et al. 2009) towards an Anthropocene that is less favourable for human living. Humanity is already operating outside of five of the nine planetary boundaries (Persson et al. 2022).

This is not a challenge awaiting the future generations, but one that requires immediate action. The impending sand crisis does not stand on its own; it is interlinked with several of the world's most urgent crises including climate change, the 6th biodiversity extinction, and increasing pollution levels. Hence, small improvements will not suffice; the society as a whole needs to transform and move towards circularity. The current linear extract-produce-use-dump economic system is not compatible with our limited resources. Given the geological time-scale, sand resources should be considered non-renewable.

One example of the systemic thinking required is the case for public transport. Instead of expanding road networks to cope with increasing mobility, we could do better in land planning, and incentivise car drivers and passengers to switch to public transport. Not only is the subway a faster mode of travel, it also reduces the vehicles on the road and the surface areas dedicated to transport. Building the necessary subway infrastructure could also, say, generate demand for alternative construction materials and reduce the carbon footprint of the current building stocks, especially when powered by renewable energy. This is the form of systems thinking that is needed.

## Next steps

These 10 recommendations highlight the many ways in which we can ensure better sand governance and management to avert a sand crisis. This report thereby aims to catalyse an international process to consolidate expertise and spur action across sectors. It is still pioneer work and more research is needed; ideally a dedicated monitoring centre would be established to monitor sand resources and activities, disseminate information and best practices, establish standards, enable cross-sector collaboration and facilitate synergies towards solutions for the sand and sustainability challenge.

An embryo for a Global Sand Centre may have just been created. This report is made of words and recommendations; to translate these recommendations into reality, actions are needed.

**It is not too late; by deciding to carry out the right actions we can still avert a crisis.**

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