Strategies for Sustainable Production and Consumption of Natural Resources

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INTRODUCTION

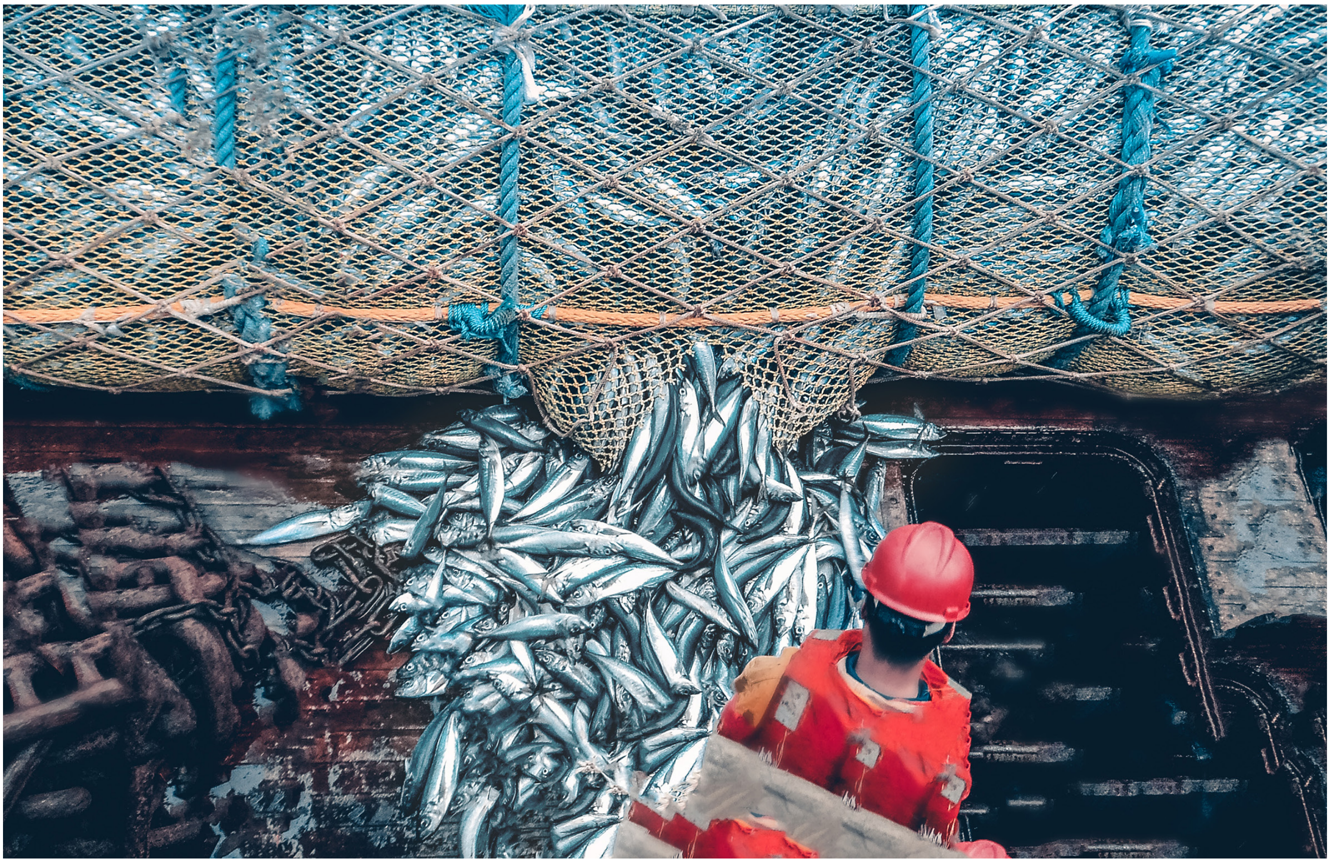
STRATEGIES FOR SUSTAINABLE PRODUCTION AND CONSUMPTION OF NATURAL RESOURCES

Natural resources encompass a wide range of physical and biological materials, entities and systems, from coal or iron ore, to a freshwater lake, North Atlantic cod, the Amazon rainforest, sunlight or the atmosphere. Some of these are exhaustible, some regenerate but can be damaged or depleted, and some are renewable and non-depletable. During the industrial era, and even more so in the era of human-made climate change, attention has been drawn to the multiple threats of unsustainable resource use.

What are the key natural resources in danger of over-consumption or depletion? What are the potential consequences of a diminishing state of the world natural resources? What is being done and can be done to reduce, reuse, recycle and replenish natural resources?

Sustainability Report

This research paper is part of a 12-month series published by The Al-Attiyah Foundation every year. Each in-depth research paper focuses on a prevalent sustainable development topic that is of interest to The Foundation's members and partners. The 12 technical papers are distributed to members, partners, and universities, as well as made available online to all Foundation members.

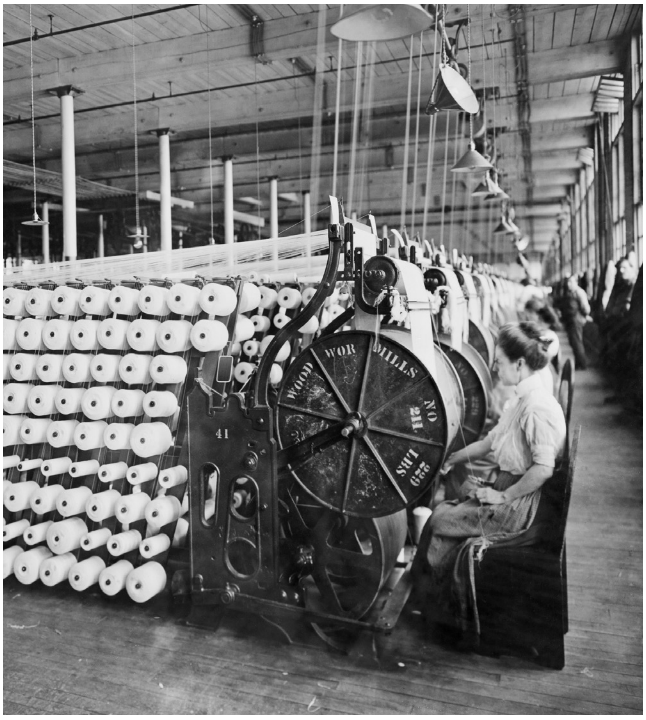


EXECUTIVE SUMMARY

- This paper primarily considers environmental sustainability, but in the context of the 3Ps – Profit, People and Planet (the holistic economic, social and environmental sustainability).
- Resources have different challenges, which are often interlinked. Solving one challenge relating to a resource can put more pressure on another resource (e.g. the water-energy nexus).
- New resources emerge as technologies are invented; older resources may remain key, may become less important or may cease to be considered as usable resources entirely.
- For the purpose of sustainability, resources can be classified into non-renewable (e.g. minerals and fuels), renewable but depletable (e.g. fresh water, fish), renewable and non-depletable (e.g. solar and wind power), and degradable (e.g. wood, paper, food material).
- Non-renewable resources are constantly in danger of depletion, while renewable resources may become depleted if over-exploited.
- The 'circular economy' paradigm is one useful approach for improving resource sustainability, when the trade-offs are properly understood.
- Policies including efficiency and recycling standards, environmental taxes and caps, technology support, supply chain certification, and international agreements, are increasingly adopted and having positive effects in some areas of resource use.

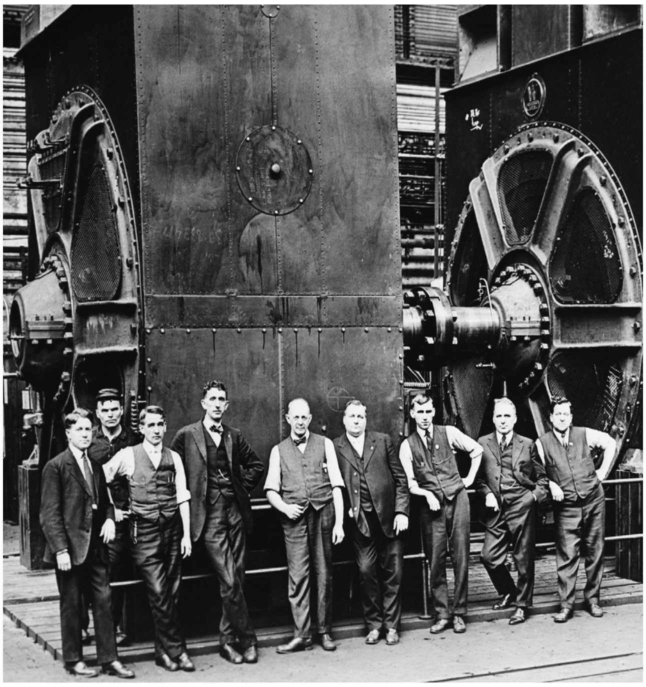
CONCERN OVER NATURAL RESOURCE SUSTAINABILITY IS NOT NEW, BUT HAS GROWN SINCE THE 1960S

Geologists have since the 1980s, and particularly since 2000, considered the most recent period of geological time to be the 'Anthropocene', in which human influence on the biosphere and atmosphere makes it quantitatively different from all other periods in time. Debate continues on whether the Anthropocene should be dated from the state of agriculture (around 12000 years before present), the Industrial Revolution (around 1780 CE), or the atomic age (1945 CE). Whichever date is chosen, human use of natural resources has been ever larger and with greater impacts. Over the past century, human use of the Earth's net primary productivity from photosynthesis rose from 13% to 25%[i]. The human population rose from an estimated 1 billion in 1804 to almost 7.8 billion in 2020, and projected to reach 10 billion by 2050.



Concerns about the unsustainable use of natural resources probably goes back to the dawn of humanity, when societies observed that big game were becoming scarcer, that a lake was becoming over-fished, or that a mine was exhausted. Ancient cultures developed methods to deal with this, including agriculture and animal husbandry, nomadism and transhumance, then crop rotation to replenish soils.

But the rise of modern industrial economies from the late eighteenth century, along with statistics and systematic scientific inquiry, gave these concerns a more organised form. English scholar Thomas Malthus, fellow of Jesus College, Cambridge, produced the seminal essay on the 'Principle of Population' in 1798, arguing



that human populations grew geometrically (exponentially) while agricultural output could only grow linearly, and therefore concluded that growing populations would face starvation. His concepts underpin much of the later work on resource scarcity, even though greatly improved agricultural productivity in the nineteenth century disproved his pessimistic predictions.

In 1865, William Stanley Jevons, a British economist, warned that Great Britain's coal would become uneconomical to produce as the best resources were exploited. American conservationist Gifford Pinchot (1865-1946) campaigned against excessive logging and worked with President Theodore Roosevelt to establish national parks and forestry reserves. From the discovery of oil in Pennsylvania in 1859, there were repeated warnings that underground petroleum was about to be exhausted, and in 1920 US government officials actually predicted that the country had just ten years of oil reserves remaining. In 1931, Harold Hotelling published 'The Economics of Exhaustible Resources', showing that the price of a finite, known, exhaustible resource should rise at the rate of interest as it was depleted.

In 1968, Paul Ehrlich, a Stanford University professor, and his wife Anne, published 'The Population Bomb', warning of over-population and mass starvation. The Club of Rome was founded in the same year, and its influential report, 'The Limits to Growth', was published in 1972. This raised the issue of resource depletion and concerns about unsustainable resource use, over population, pollution, and nuclear weapons.

THE CONCEPT OF SUSTAINABLE DEVELOPMENT

In the past few decades, the global community's rising interest in sustainable development has evolved through several phases. There have been several attempts to define sustainable development, but none have endured and received universal acceptance as the Brundtland definition – "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

It is generally accepted that three pillars of sustainable development are inherent in the Brundtland definition – economic development, social progress, and environmental management (and conservation) – the so-called three overlapping circles. Over time, it became common practice to add a fourth dimension (governance) which transcends all the other three pillars.

The evolutionary process of sustainable development is depicted by the moving shift in the global focus on each of the three pillars and their relation to each other (Figure 1). Four distinctive phases could be recognized in this evolutionary process. At each evolving phase, the definition, nature and scope of the concept widens significantly, raising the stakes and spectre of international community's interest and engagement in the sustainable development debate.

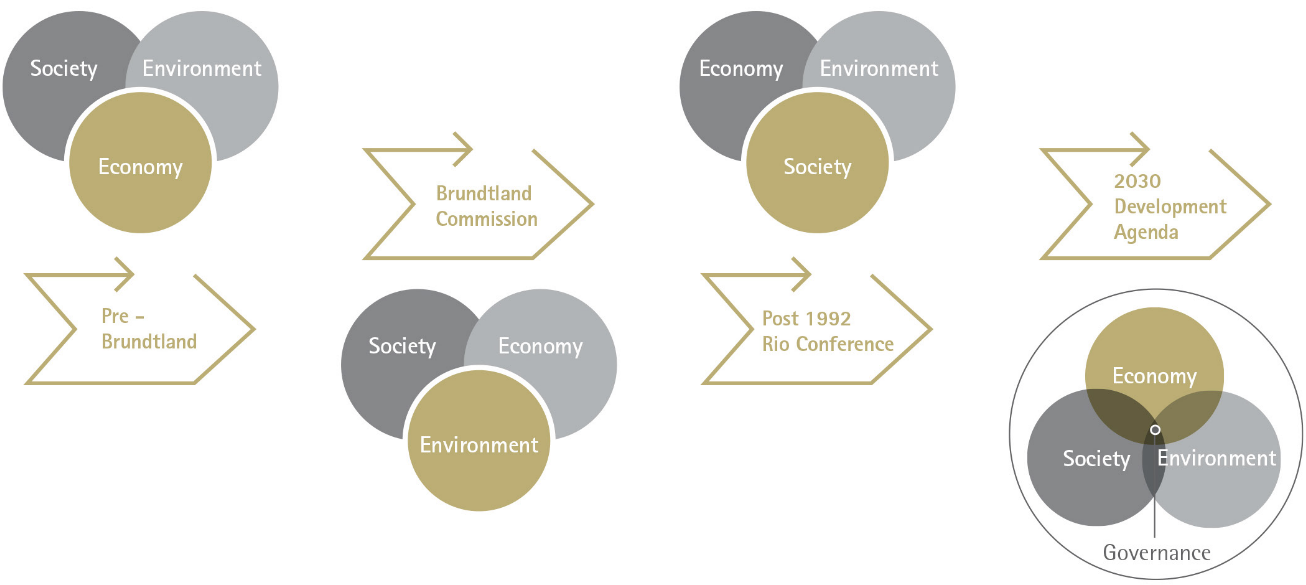
Pre-Brundtland Phase

The pre-Brundtland definition was characterized with predominant focus on economic development, without much attention paid to environmental conservation. Environmental awareness was generally poor.

Brundtland Commission

The growing environmental campaign in the late 70s and early 80s, led to the establishment of the Brundtland Commission in December 1983, by the United Nations General Assembly. The Commission, chaired by Ms. Gro Harlem Brundtland, the Prime Minister of Norway at the time, developed what is widely referred to as the Brundtland definition of sustainable development. The definition was contained in a unanimous report, Our Common Future, produced by the 22-member Commission, and presented to the UN General Assembly in October 1987.

FIGURE 1 THE PROGRESSIVE SHIFTING IN FOCUS OF SUSTAINABLE DEVELOPMENT



The Brundtland definition inadvertently shifted the focus of sustainable development to ecology and biodiversity.

Post 1992 Rio Conference

The United Nations Conference on Environment and Development (UNCED) – the Earth Summit – which took place in Rio de Janeiro in June 1992, was a milestone event that shaped the framing of the global sustainable development agenda. Growing global debate on sustainable development since the summit shifted the world focus to a more anthropological perspective where increasing emphasis is placed on human condition and quality of life. The Rio Declaration on Environment and Development and the Agenda 21 document were adopted by world leaders at the Earth Summit, for all nations to use in defining their work program, for the 21st century, in all areas of sustainable development.

2030 Development Agenda

In 2001, governments adopted the millennium development goals (MDGs), and in 2015 replaced them with the sustainable development goals (SDGs). The SDGs are a new, universal set of goals, targets and indicators that all UN member states are expected to use for framing their sustainable development agendas and policies for 15 years, post 2015. The MDGs and SDGs ushered in an era where environmental, social and economic considerations, in perfect harmony with transparent governance, has become the hallmark of sustainable development best practice, among companies of all shapes and sizes worldwide. This is increasingly recognized by all major stakeholders in the global sustainable development debate as representing a pragmatic approach.

NON-RENEWABLE NATURAL RESOURCES

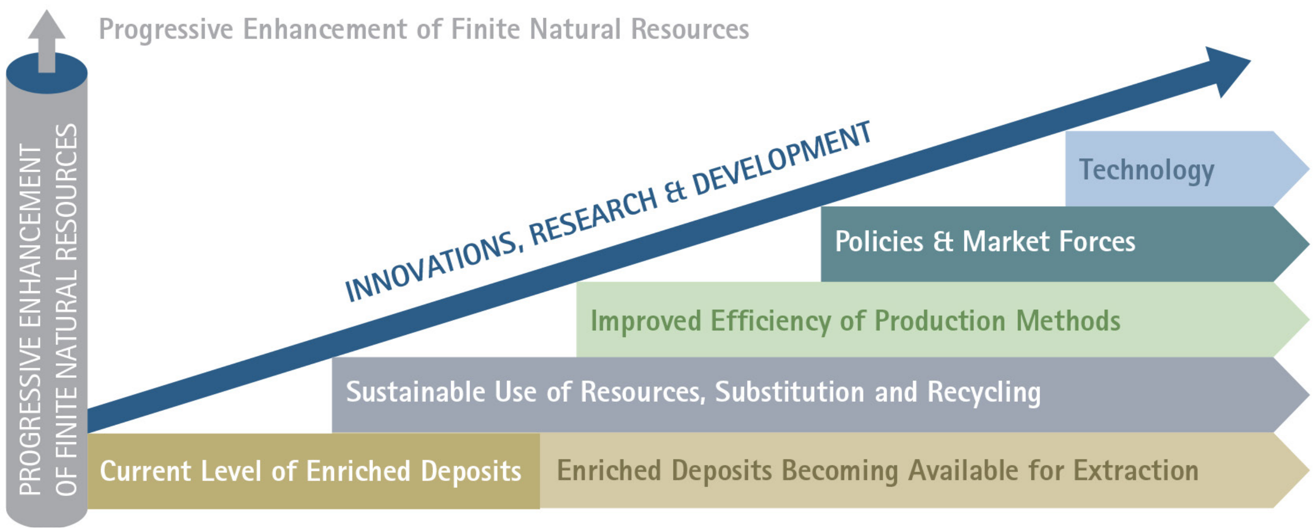
At a simple glance, it is probable to see why the purists argue that according to Brundtland definition, extraction of natural resources cannot be sustainable because of the finite nature of the resources. However, with the way the concept has evolved since Brundtland, the natural resources sectors could embrace a broader focus of sustainable development that emphasizes the human condition and quality of life issues, as well as, ecological and environmental aspects.

This broader focus set the key premise for sustainable production and consumption of depletable non-renewable natural resources. The ability; through appropriate government regulations, international treaties, and industry best practices; to convert natural resources capital into new forms of capital, such as, economic, social and human capital, all of which are essential requirements for attaining the UN SDGs.

This can be contextualized through careful consideration of how non-renewable resources can be exploited, in a sustainable and environmentally responsible ways, to contribute to national wealth and serve as a springboard and cornerstone for sustainable development and social stability. Such consideration may include:

- The dependency and pervasive use of natural resources in modern society, which will continue into the foreseeable future;
- The abundance of non-renewable natural resources, coupled with recycling, better production methods, development of technologies, and the continual identification of new reserves; that makes the fear of running out of natural resources in the foreseeable future, unrealistic (Figure 2);
- The increasing realisation, through the work of many international agencies, that poverty is the most immediate and greatest threat to man, in today's world. Poverty is associated with reduced life expectancy, and results in significant impact on the environment due to unstainable consumption of natural resources;

FIGURE 2 CONTINUOUS ENHANCEMENT OF AVAILABILITY OF NATURAL RESOURCES THROUGH INNOVATION AND TECHNOLOGY



- Recognition that, by creating wealth, particularly in developing countries, exploitation of natural resources, plays an important role by serving as seed and springboard for sustainable development; and
- Sustainable production of natural resources leads to the creation of lasting infrastructure, such as roads, telecommunications, electrification, hospitals, schools, and so on.

NATURAL RESOURCES CAN BE CLASSIFIED ACCORDING TO TYPES OF DEPLETION AND SUSTAINABILITY CHALLENGES

In the context of sustainability, natural resources can be classified into the following four major categories (See Table 1):

1. Non-renewable, exhaustible resources
2. Renewable, exhaustible
3. Renewable, non-exhaustible
4. Degradable / carrying-capacity

TABLE 1 CLASSIFICATION OF RESOURCES BY SUSTAINABILITY CHARACTERISTICS

<table>
<tr><th colspan="2">Resource type</th><th>Examples</th><th>Key characteristics</th><th>Sustainability Challenges</th></tr>
<tr><td rowspan="3">Non-renewable, exhaustible</td><td>Metals and miner-als</td><td>• Traditional: iron ore, copper, silver, lead, salt, diamonds, bauxite, uranium, sulphur, building sand, limestone, phosphates
• Emerging: rare earth minerals, lithium, cobalt, graphite, nickel, platinum, thorium, helium</td><td>• Very large in-situ resources of most (with a few exceptions, e.g. tellurium, helium)
• Costs and environmental impact may increase as lower-grade / more remote resources are exploited
• Often substitutable and recyclable</td><td rowspan="3">• Associated environmental damage, including land degradation from open-pit mining; oil spills and leakage or collapses from tailing pits and spoil heaps;
• Greenhouse gas emissions from methane leakage and fossil fuel power for operations;
• Radioactive waste from nuclear power;
• Water use in arid regions and water contamination;
• Rising extraction intensity as exploited deposits are deeper, more remote or technically difficult;
• Damage to biodiversity;
• Danger and hard working conditions to miners, particularly artisanal miners in sectors such as Congo's cobalt deposits;
• Negative social and economic impacts to local communities (boom-and-bust cycles) and even the national government (the</td></tr>
<tr><td>Fossil fuels</td><td>• Oil, gas, coal / lignite, peat
• Conventional and non-conventional (e.g. oil sands, shale oil, oil shale / kerogen, gas hydrates)</td><td>• Very large resources
• Unlikely to be practically depleted given climate change issue, but costs and environmental impact may increase
• Not recyclable
• Can be substituted with electricity and synthetic fuels in many applications
• Also non-combustion uses (e.g. petrochemicals / plastics)</td></tr>
<tr><td>Fossil water</td><td>• Old subsurface aquifers with little present-day replenishment</td><td>• Key for agriculture in many semi-arid / arid areas
• Can be recharged</td></tr>
</table>

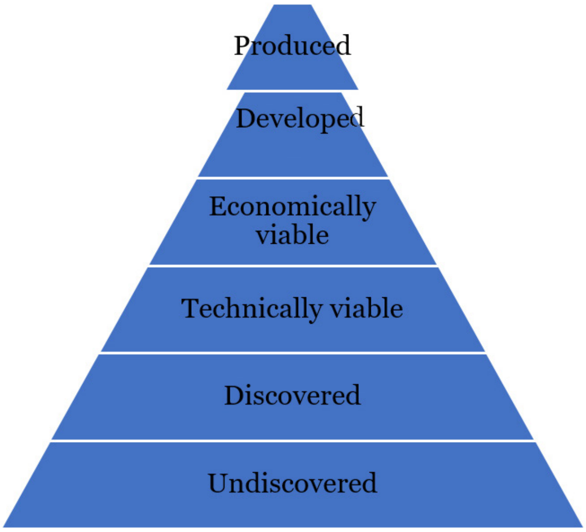
	Fossil water	little present-day replenishment	many semi-arid / arid areas • Can be recharged artificially	economic impacts to local communities (boom-and-bust cycles) and even the national government (the 'resource curse').
Renewable, exhaustible		• Wild animals (whales, elephants, polar bears, etc), fish, old growth trees, fresh water, coral reefs • Ecosystems (e.g. Amazonian rainforest)	• Reproduce or renew themselves, but can be depleted to the point of exhaustion / extinction and then cannot be regenerated (in the case of living creatures) • Vulnerable to environmental change and expanding human populations / settlements, even when not actively hunted • Depend on their ecosystem, so can become endangered through loss of other species • Can be substituted, but often have important prestige / social roles	• Over-exploitation leading to ecosystem collapse; • Transformation of ecosystems, for example conversion of rainforests to cattle pastureland or palm oil plantations; • Desertification from loss of water resources (e.g. because of diversion or over-use of rivers, or hydroelectric dams, as with the Aral Sea in Uzbekistan / Kazakhstan, the Colorado River in the south-western USA, the Tigris-Euphrates system in Turkey, Syria and Iraq) or from over-grazing, deforestation or other unsustainable land use; • Exposure to zoonotic pandemics and parasites; • Production of greenhouse gases, such as carbon dioxide from forest and peatland fires, methane from rice paddies and nitrous oxide from fertilisers; • Social impacts from displacement of local / indigenous people.
Renewable, non-exhaustible		• Wind, solar, hydropower, geothermal (to an extent), tidal, wave	• Resource size is finite but often very large compared to likely demand • Best sites will be exploited first but improving technology lowers costs • Are not depleted by use • Exploitation can cause environmental damage	• Land-use change, as technologies such as wind and solar require large land areas, even if combined uses are often possible; • Noise and visual pollution; • Flooding by hydroelectric dams, displacing people and ecosystems and destroying historic sites; • Resource use and pollution, including energy and water consumption, for producing high-purity silicon, rare earths, lithium, steel, concrete and other materials used by

Renewable, non-exhaustible		• Resource size is finite but often very large compared to likely demand • Best sites will be exploited first but improving technology lowers costs • Are not depleted by use • Exploitation can cause environmental damage	uses are often possible; • Noise and visual pollution; • Flooding by hydroelectric dams, displacing people and ecosystems and destroying historic sites; • Resource use and pollution, including energy and water consumption, for producing high-purity silicon, rare earths, lithium, steel, concrete and other materials used by renewable energy systems;
Degradable	• Atmospheric greenhouse gas capacity, ozone layer, nitrogen cycle, phosphorus cycle, arable land, ecosystem services, water salinity, subsurface CO2 storage space	• Are not exhausted, but can be degraded, making them unusable or having other negative consequences (e.g. climate change) • Can often be restored with careful management	• Fresh- and sea-water contamination by, inter alia, heavy metals, oil, excess fertiliser (causing algal blooms and low-oxygen 'dead zones'), plastics, excess carbon dioxide (ocean acidification), sediment from erosion (blocking photosynthesis and damaging coral reefs), noise from ships and seismic surveys (harming marine mammals); • Underground storage space for carbon dioxide injected during carbon capture and storage (CCS); • Atmospheric, oceanic and biosphere capacity for greenhouse gases, causing climate change; • Cycles of key nutrients, notably the nitrogen and phosphorus cycles, where additional and potentially excessive levels are added by human activity.

NOT ALL RESOURCES ARE PRACTICALLY OR ECONOMICALLY VIABLE

As illustrated in Figure 3, the resource pyramid for non-renewable resources depicts the status and quantities of non-renewable resources, that shows that, as exploration proceeds, resources are transferred from undiscovered at bottom, towards production at the top of the pyramid. Not all resources are technically and economically viable, but improvements in infrastructure and technology and increases in price will move more resources into viability. Over time, more and more of the resource base become viable and the quantity of the resources produced grows.

FIGURE 3 RESOURCE PYRAMID FOR NON-RENEWABLE RESOURCES

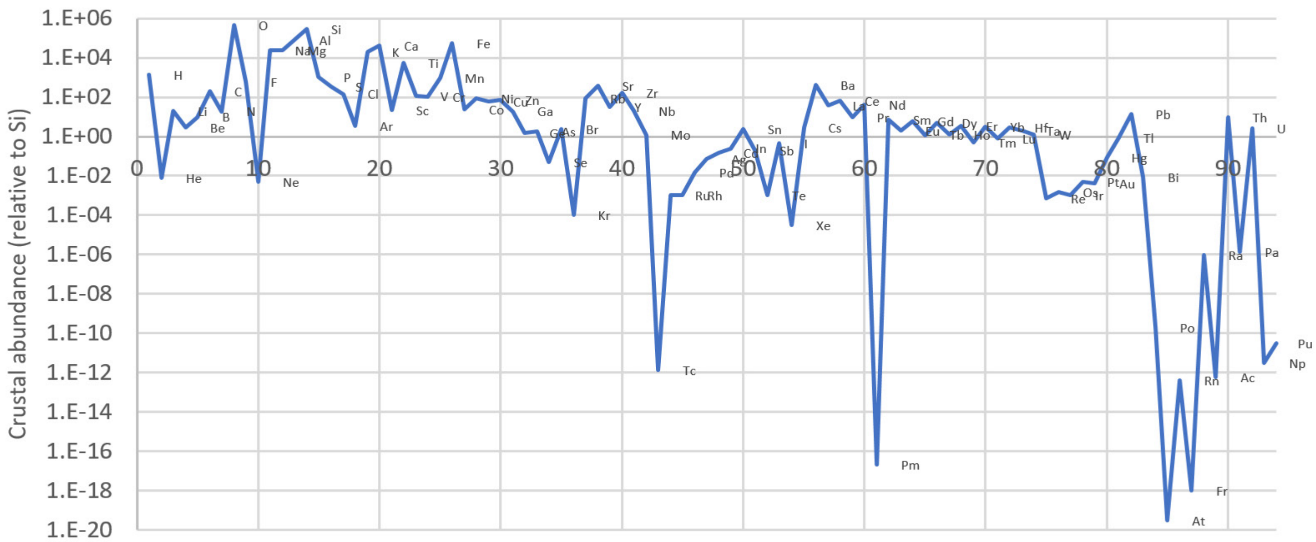


However, it is not simple to say that the resource is thereby being depleted. Obviously, the discovery and extraction of a non-renewable resource diminishes the quantity in the ground. But for most economically important resources, this quantity on a global scale is very large relative to long-term projected demand. The Club of Rome erred in assuming that reserves-to-production (R/P) ratios, expressed in years, were a valid measure of time to depletion. In fact, current commercial reserves are more of a working inventory, which is replenished by exploration and extension of known finds. It is economically inefficient to find resources well in advance of a time when they will be needed.

As shown in Figure 4 elements vary widely in crustal abundance. However, this does not tell the whole story of their availability as some typically occur in high concentrations in limited areas.

The availability of most minerals is therefore a matter of economics and technology, not physical abundance. This may be somewhat different for fossil fuels, which are found in significant quantities only in sedimentary rocks and in the upper few kilometres of the crust. It may also be different for some specific physical and chemical forms of elements, for instance graphite (a form of carbon) for batteries.

FIGURE 4 CRUSTAL ABUNDANCE OF ELEMENTS BY ATOMIC NUMBER



LEVELS OF THREAT OF UNSUSTAINABLE USE

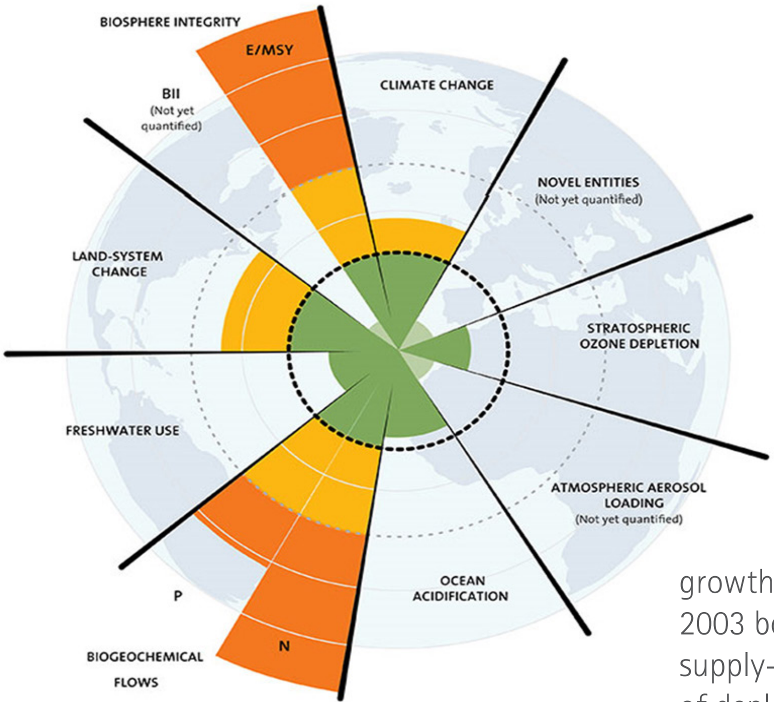
The level and effects of non-sustainable use of natural resources vary considerably. Some resources are being exploited sustainably, others at very low level of unsustainability, and for some in certain geographic areas, the levels and impacts of unsustainability are already at crisis proportions.

The Stockholm Resilience Centre has defined nine 'planetary boundaries', relating to the 'carrying capacity' of the components of the ecosystem. Of these, 2½ of the planetary boundaries are not yet quantified, three are considered to be at safe levels, two are at increasing risk, and 1½ at high risk (Fig. 5).

The level of uncertainty and the lack of understanding of the current status of resources, the connections between them, and the future consequences of unsustainable exploitation, is indicative of a major problem in sustainable resource use.

As Figure 6 shows, there are no direct correlations between movements in prices and

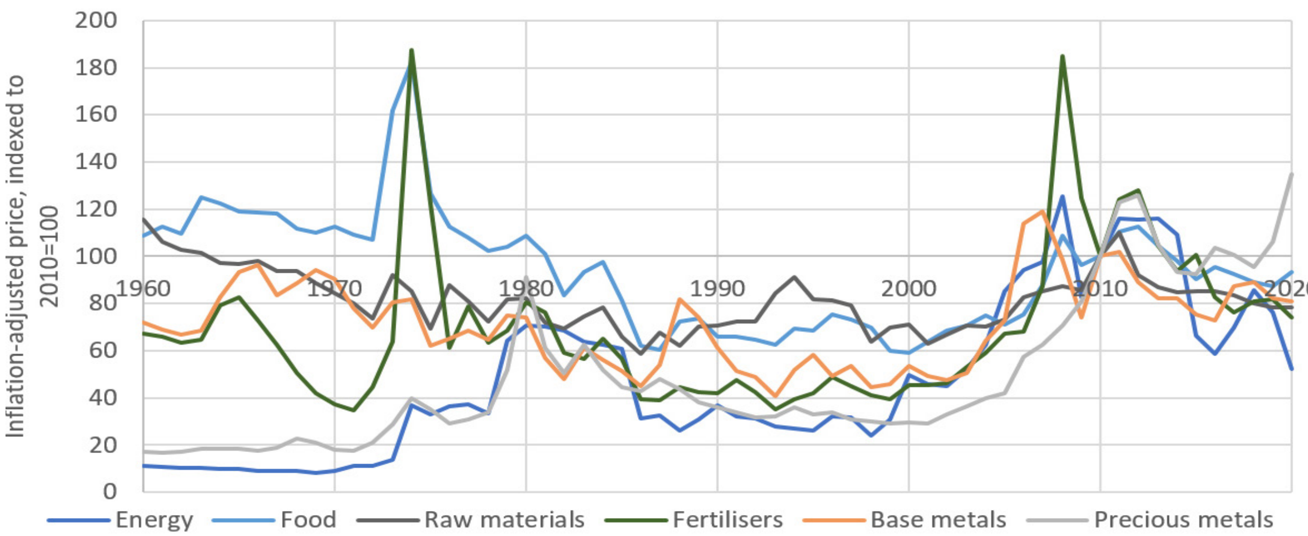
FIGURE 5 THE NINE PLANETARY BOUNDARIES (BII = BIODIVERSITY INTACTNESS INDEX; E/MSY = EXTINCTIONS/ MILLION SPECIES-YEARS; P = PHOSPHORUS; N = NITROGEN)[ii]



depletion of natural resources Prices for most commodities generally rose in the mid-1970s, fell during the 1980s, stayed low during the 1990s, then rose significantly in the early 2000s before falling again. These trends rather followed the prevailing cycles of economic growth and investment, such as China's post-2003 boom, and in the case of energy, OPEC's supply-side restrictions, rather than as a result of depletion.

The concern about over-population is also often blown out of proportion. While over-population can indeed lead to unsustainable land use, deforestation, water use and other impacts on natural resources, the level and pattern of consumption are often the major issues. Densely-populated countries, like the

FIGURE 6 PRICE INDICES FOR GROUPS OF RESOURCES, 1960-2020 [iii]



Netherlands, South Korea and Singapore, for example, are able to maintain high levels of living standards, even though they require inflows of resources from elsewhere.

IMPACTS OF NON-SUSTAINABLE RESOURCE USE

The impacts of non-sustainable resource use depend on the type of the resource and the nature of the non-sustainability. Impacts may be environmental, social or economic, or, usually, a combination.

Environmental impacts include the various negative consequences, such as, biodiversity loss, pollution, climate change. These impacts, in turn, can negatively affect human health and the economy. This includes the cost of clean-up or providing substitute resources, the damage to businesses such as tourism, and the expenses of healthcare and greater morbidity and loss of years of productive life. Environmentally-damaged areas, such as the areas of the Niger Delta hit by oil spills or the US 'Rust Belt', can become sites for political unrest or discontent, economic depression and crime.

SUSTAINABLE RESOURCE USE AND THE CIRCULAR ECONOMY

The 'circular economy' has become a popular aspiration for managing resource use.
The concept of circular economy, in its various formulations, is aimed at an ideal framework of no wastage of resources.

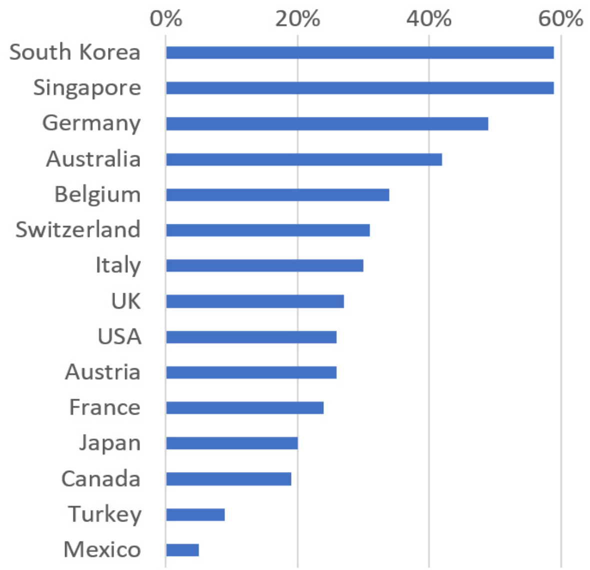
The framework for circular economy, usually follow a hierarchical process that may include some of the following[iv]:

- Rethink: re-design business practices and lifestyles to require less material input, for instance rental rather than purchase, and teleworking rather than commuting;
- Reduce: use lean design principles and efficiency to consume less energy and materials;
- Re-use: pass on used items to others, buy second-hand, and find new uses for older items;
- Repair: rather than throwing away, repair items to keep them in use, and design objects that can be easily repaired;
- Refurbish or re-purpose: employ business models that upgrade older items so they can be re-used, or use their components in new items;
- Recycle: dissemble item into their component materials that can be used again;
- Recover: capture embodied energy by combustion or (for organic waste) use as fertiliser.

From the point of view of resources, we can also add:

- Replenish: ensure natural systems are maintained in a healthy condition to continue providing natural resources[v].

FIGURE 7 RECYCLING RATES, MUNICIPAL SOLID WASTE

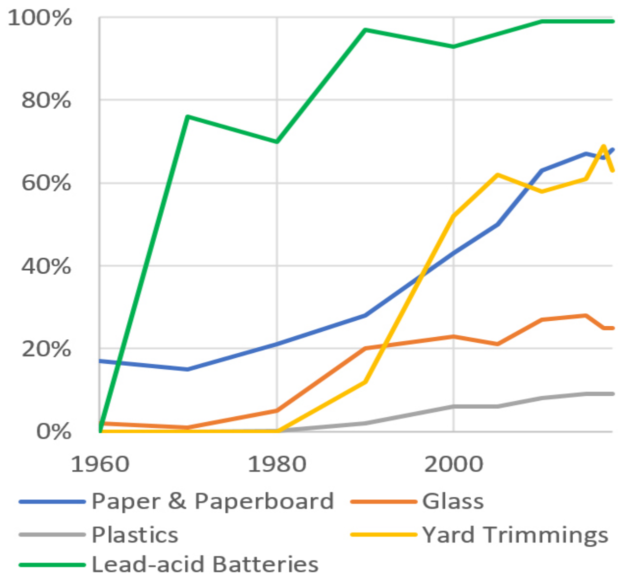


In reality, some level of material waste is inevitable at each stage of manufacture and use. Economic growth demands a larger quantity of resources, even with increasing efficiency of use. Sometimes, goals are in harmony, for instance lighter vehicles that require less energy to move. Sometimes they are in tension, as with insulation that saves energy but requires more plastics, or a robust, long-lived item that is hard to recycle. Recycled materials, such as paper and plastics, are often lower-quality than the primary material and have more limited uses.

Recycling rates vary widely, as shown for some selected countries in Figure 7, suggesting that substantial potential exist for several major economies, to double their recycling rates.

Recycling rates for different materials have generally been on the increase since 1960 (Figure 8). However, the rates still remain surprisingly low for some materials that are relatively easy to recycle and where recycling is expected to have large energy savings, such as glass. Attention has recently turned to retrieving scarce metals, including lithium, cobalt, nickel, manganese, silver and gold, from electronic goods and renewable energy systems. Only 5% of lithium-ion batteries in the EU and US are currently recycled. As well as saving costs and the environmental impacts of new metal extraction, recycling also prevents the leaching of these metals from landfills into groundwater[vi].

FIGURE 8 RECYCLING RATE OVER TIME FOR DIFFERENT MATERIALS, USA [vii]



Replenishment requires an understanding of how a species or ecosystem is dependent on other parts of the global ecosystem, including nutrients, water, predator-prey relationships, invasive species, climate and other factors. This could involve technologically complex or ethically questionable practices, including genetic engineering and "de-extinction"[viii]. A less invasive approach, "re-wilding", including the re-introduction to the former historic ranges of species and allowing natural ecosystems to reappear, has been gaining popularity[ix].

POLICIES AND RELEVANT BODIES

More sustainable use of natural resources has to be encouraged by individual, corporate and civil society action, as well as by governments. Market mechanisms (i.e. prices) generally deal well with issues of physical resource depletion, at least for non-renewable resources that are not subject to competitive exploitation. However, market mechanisms do not address well, the indirect consequences and associated social and environmental problems of resource exploitation.

Key international agreements relevant to sustainable resource use include:

- the Montreal Protocol on ozone-depleting substances;
- the Kyoto Protocol and Paris Agreement on climate change;
- the UN Convention on the Law of the Sea and the International Seabed Authority which it established;
- the OSPAR Convention on protection of the North Atlantic[x];
- the Ramsar Convention on Wetlands[xi];
- and various conventions within the UN, EU, ASEAN and other regional bodies on trans-boundary pollution, sustainable fisheries, environmental regulation of shipping via the International Maritime Organisation, and many other areas.

Within countries and regional blocs, a host of policies and regulations deal with the sustainable use of natural resources, though several of these need strengthening in many areas. Such policies include direct regulations to increase efficiency, limit pollution and land-use disruption, involve public consultation, and require Environmental Impact Assessments for major projects. Quotas for fishing aim to limit take to sustainable levels, though negotiation and enforcement is challenging. Tradable rights to use natural resources, such as water, or sulphur and CO2 emissions permits, have become increasingly popular. Fees or taxes to correct negative "externalities" of resource extraction and use, offer an economically-efficient approach, which should encourage innovation more than traditional "command and control" regulation. Government support for research and early deployment of new resource-efficient technologies has been an important theme since at least the 1970s oil crises.

Policies on sustainable resource use need to consider indirect effects. For instance, the EU's initial biofuels mandates were intended to cut greenhouse gas emissions from transport, but have been blamed for encouraging deforestation, burning of peatlands, and the establishment of low-biodiversity monocultural palm oil plantations. Later iterations have strengthened protection for sustainability. Technology companies are beginning to pay attention to ethical sourcing of their critical raw materials, such as cobalt from artisanal miners in Congo, or systems, such as solar panels, which may be made in China by forced labour. However, companies, consumers and governments have to be willing to demand and pay appropriately for sustainable supply chains.

IMPLICATIONS FOR LEADING OIL AND GAS PRODUCERS

There is no particular concern about the depletion of oil and gas resources at a global level, although of course individual producers may face depletion and falling output from their fields. New resources, such as heavy oil, shale oil, gas hydrates and enhanced oil recovery are, with conventional fields, more than adequate to meet demand for multiple decades. Oil and gas consumption in the 2030s and beyond appears more likely to be limited by climate policy and by competition from alternatives, notably electric vehicles and renewable energy.

Nevertheless, greater sustainability of hydrocarbon extraction remains important to limiting its environmental impact and retaining as much public and political support as possible. This includes eliminating flaring and methane leaks, improving upstream energy and water efficiency, limiting water and air pollution, decommissioning and disposing of offshore structures in a sustainable and safe manner, and ensuring social and community sustainability in petroleum-producing areas.

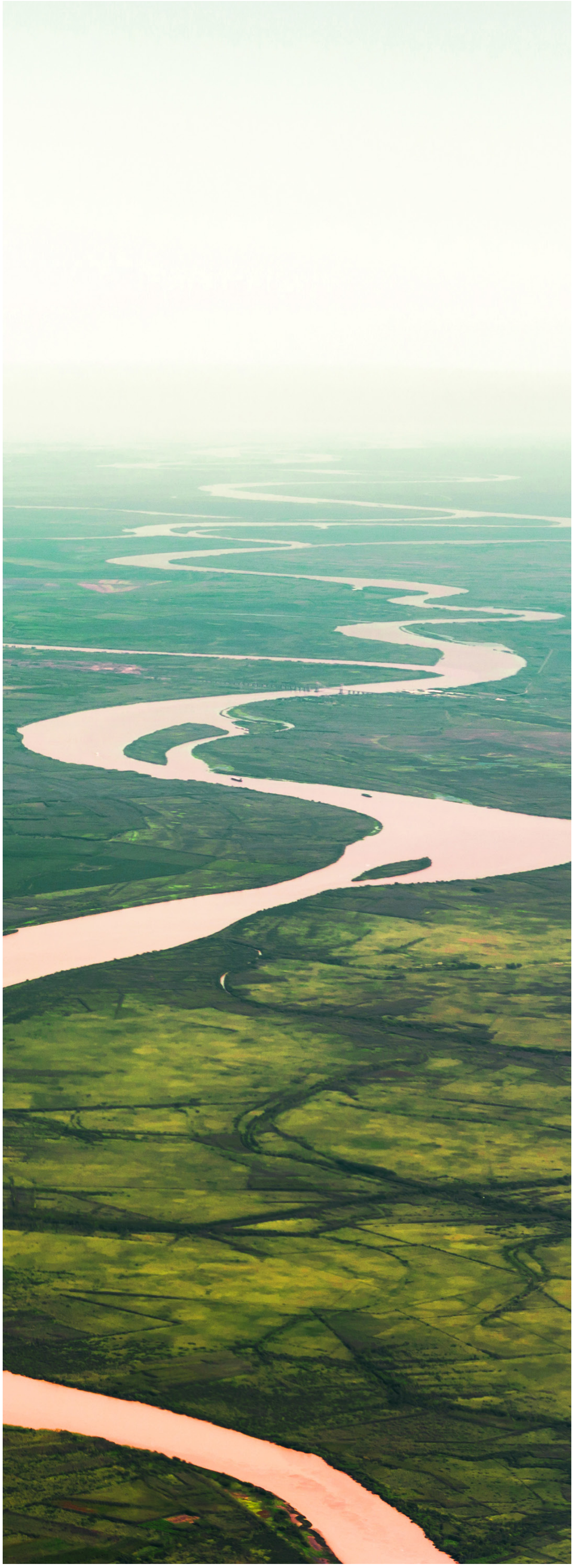
The transition to low-carbon energy system faces some particular resource issues. These issues need to be taken into account when forecasting the likely speed and scale of growth of new alternative energy technologies. They include access to sustainably-produced critical minerals, water use (for biofuels), and land use (for biofuels, hydroelectric power, wind and solar).

The oil and gas industry can seek out complementary opportunities for sustainable resource use, such as, CCS; hydrogen; use of old wells to extract geothermal heat and lithium-rich brines; treating and reuse of saline oil-field waters for agriculture; repurposing offshore structures as artificial reefs; and using oil industry technologies for offshore wind and wave power and geothermal drilling.

CONCLUSIONS

Sustainable resource use is a wide and complex, and sometimes counter-intuitive, topic. Solving a problem with one resource often puts further stress on another resource. Certain resources, including water, energy, atmospheric capacity for greenhouse gases, nitrogen and phosphorus, have major transboundary implications. There is need to continue to strengthen international cooperation on issues such as, transboundary pollution, watersheds, and fishing grounds.

Some concepts associated with sustainable consumption of natural resources, may be compatible with free-market capitalism; while others may not. With some exceptions, the push towards managing resource sustainability, over the last fifty years and more, has been largely driven by market economy, with some limited government intervention. Concern about the impacts of climate change is becoming a dominant force, that is demanding more drastic measures on ensuring sustainable utilisation of resources. There are many policies in place, and more are being introduced, to tackle unsustainable resource use. They are often effective in places, but a more holistic and interconnected approach is required to make a true leap forward.



APPENDIX

i. https://www.annualreviews.org/doi/full/10.1146/annurev-environ-121912-094620
ii. https://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html
iii. Data from https://www.worldbank.org/en/research/commodity-markets
iv. https://medium.com/@beta__i/the-7-rs-of-the-circular-economy-11d27e933f01
v. https://www.amazon.com/Replenish-philosophy-living-harmony-nature-ebook/dp/B07B4XQPXB
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ix. https://rewildingeurope.com/what-is-rewilding/
x. https://www.ospar.org/convention
xi. https://www.ramsar.org/

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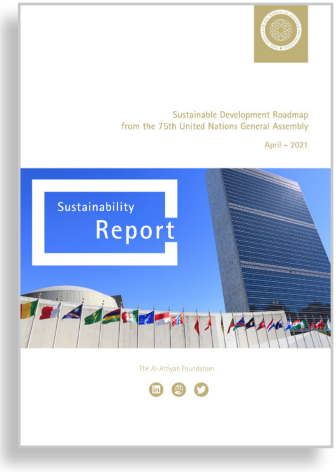

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OUR PARTNERS

Our partners collaborate with The Al-Attiyah Foundation on various projects and research within the themes of energy and sustainable development.

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