TEEB for Coasts Report

A proposal for an inclusive and comprehensive assessment and evaluation framework to improve decision making and achieve sustainability and equity in coastal areas

This document demonstrates how a framework for measuring changes in capital stocks and associated flows of impacts can help in the coastal context, providing Proofs-of-Concept and integration with extant and emerging efforts

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Background

Following the publication of the TEEB Synthesis report for the Convention on Biological Diversity Conference of the Parties in 2010, TEEB entered into an implementation phase. This was in recognition of the increasing demand for support from decision makers wanting to put the recommendations from the original TEEB studies into practice.

This implementation phase of TEEB has delivered major advances in the fields of natural capital accounting, in how businesses understand their impacts and dependencies on the natural world and especially in advancing the analysis of policy choices around the sustainability of the food systems.

Oceans and coasts have long been of interest to TEEB, a discussion paper “Why Value the Oceans?” beginning this exploration was originally published in 2012.

The beginning of the International Decade of Ocean Science and the success of the TEEB AgriFood Initiative – which at the time of writing is actively working with decision makers and researchers in 10 different countries – make this a timely point at which to re-examine what TEEB can offer coastal decision makers, especially understanding the lessons learned from TEEB AgriFood to help contribute to long term sustainable management of our coastal assets.

Executive Summary

The Economic of Ecosystems and Biodiversity is about making choices. It is about addressing the economic invisibility of nature. It is about reorientating our economic compass away from the narrow pursuit of financial gain and towards sustainable development. And, recognizing that we cannot take a new direction without new metrics. We need to measure what matters to us and reflect this in how we understand and select from the options available to us.

In this context TEEB for Coasts is intended to respond to the challenges faced by our coasts.

The IPBES Global Assessment reflects that whilst coastal areas host some of the most ecologically productive systems on the world, coastal habitats have already been severely impacted by sea and land uses changes. Negative drivers of change range from coastal development, offshore aquaculture, mariculture and bottom trawling to onshore land clearance and urban sprawl along coastlines, and pollution of rivers and climate change. Demands impacting the coast are also increasing rapidly. The demands in the coastal environment include the need to provide food, transportation and trade, renewable energy generation, as places to live and places enjoy our leisure time. These demands illustrate the immense value that we receive from marine and coastal spaces. As these pressures converge the tradeoffs we are making by allowing the destruction and degradation of coastal habitats remain hidden. Like the shared dependence of that multiple economic actors/sectors have upon the same set of natural assets, they remain unexplored, as the relationships are invisible to current economic metrics.

We address this need to reveal the value we get from the sea through examining what a TEEB for Coasts Evaluation Framework should encourage decision makers to measure if we are to identify and deliver opportunities for sustainable development in the coastal zone.

Sustainable development, as highlighted by the recent Dasgupta Review of the Economics of Biodiversity – from an economic perspective – requires us to think about societal wealth, or society's stock of capital. This is because, for wellbeing to increase, and for that increase to be sustained over generations, it must be based on an increasing stock of capita. Capital assets in economics are those 'goods' which endure (if maintained) and produce a flow of benefits throughout their lifetime, so having a greater stock of capital translates to a greater flow of benefits. It is critical however to measure wealth, or the total stock of capital, comprehensively, which means incorporating natural capital – the natural assets which provide flows of benefits over time. Without this we risk mis-measuring our wealth, as is currently occurring, through having an indicator – like GDP – which can be driven up by actions which damage and destroy nature in spite of the threat this poses to people both now and in the future. We therefore advocate the adoption of a capitals approach – reflecting the four capitals examined in the TEEB AgriFood Framework – Human, Social, Produced and Natural Capital which collectively define our ability to meet human wants and needs. Given the focus on TEEB on the values of nature in the context of inclusive and sustainable development, a strong focus is placed on revealing the invisible flows connected in particular to natural and social capital.

As multiple sectors interact in the coastal zone, and the dynamic nature of the environment enhances the connection between locations, the TEEB for Coasts Evaluation Framework also needs to address the interconnectivity between sectors which impact or depend upon the coasts. Whilst this is complex it is aided by taking a capitals approach as it becomes more readily observable where two sectors have a

shared connection to an asset. For example, it may become apparent that a hotel, which appeared to be a good investment from a financial perspective, may be a bad choice from a societal perspective. This is because the financial calculation would fail to account for the wider impacts of the hotel construction. For example, if a mangrove forest needed to be removed in the construction process, the financial cost of carrying this out would be estimated. However, the impacts on the livelihood of local crab fishers, the hotel staff whose homes are no longer protected from storm damage or the potential feedback on visitor numbers if populations of fish caught by sport fishers decline as a result of habitat loss for their juveniles would all be missed. Such flows – ignored by the hotel investor – would be more readily captured in an assessment which shows the uses of and impacts on capital stocks, and engages the other local actors who also use and depend upon those stocks.

Enormous trade-offs already exist; high concentrations of persistent organic pollutants, heavy metals and plastics in coastal waters – largely from land-based sources – are already associated with global harm, including to health impacts worldwide through the poisoning of coastal fish harvests[1]. Likewise, the loss of coastal habitats will leave over half a billion people more exposed to sea level rise and extreme weather events[2].

These connections can no longer be neglected and need to be recognized in the choices we make about managing economic activity that impacts our coasts.

The TEEB for Coasts provides a logical framework to untangle the complex socio-ecological system, understand the implications of decisions and reorientate the economy towards sustainable development. Whilst completing such a comprehensive assessment will no doubt be challenging, waiting for perfect information is not an option. As reflected in a series of expert workshops held in the preparation of this Interim Report, even where relationships cannot be quantified, the process, engagement and thinking required to apply the evaluation framework, means that TEEB for Coasts remains a great opportunity to help break down sectoral and ministerial silos, to reveal hidden trade-offs and rebalance our the relationship between the economy, people and nature in the coastal zone.

This document provides an overview of TEEB for Coasts through exploring the following issues over the course of the next chapters:

- **Why is TEEB for Coasts Needed?** - An exploration of decision making without, and with, full information
- **How could TEEB be used to understand coastal areas and issues?** - Making the invisible visible – what should we measure?
- **What is capitals-based systems thinking?** - Stocks, flows, impacts and dependencies
- **Achieving a Sustainable Blue Economy:** scenarios, trade-offs and decision making for sustainability
- **What is the TEEB for Coasts Evaluation Framework?** – Bringing it all together to guide capitals-based systems thinking in coastal areas

[1] IPBES Global Assessment Report - Summary for Policymakers p29 – point 13
[2] Global modeling of nature's contributions to people | Science (sciencemag.org)

The Evaluation Framework developed in this report is a draft, it needs to be supported by more detailed implementation guidance and piloted in real world contexts.

Why is TEEB for Coasts needed?

1 INVISIBLE COSTS

1.1 Coastal stakeholders and decision makers' interests

The coastline of the world is over 1,634,701km long, and is often the most densely populated region of coastal countries. Coastlines are incredibly variable, containing a myriad of habitats, species and ecosystem services, and these resources are critical to the local communities. From sourcing nutrition, to providing protection and employment, the coastline is vital to humans across the globe. As well as providing essential resources, coastal areas have significant cultural value to surrounding populations. It is estimated that 13% of the global urban land mass is in coastal areas, including some of the largest cities, such as Rio de Janeiro, Mumbai and New York[3]. These numbers are expected to increase substantially by 2025, and urbanisation of the coastal areas will have to grow accordingly. Around 60 million people are thought to be employed worldwide in fishing and fish farming sectors alone[4], which underpin the many of the economies and health of the populations. Anthropogenic changes such as climate change and urbanisation have a disproportionate effect on coastal areas, as they are often sensitive to environmental changes such as temperature fluctuations, sea-level rise and extreme weather events.

Habitats along the coastline are diverse, including mangroves, beaches, seagrass and saltmarshes, and coral reefs, and the varying spatial scales and geographical regions covered make it a particularly complex challenge to understand all the different services provided. Along with this, there are many complex and interlinking relationships between these habitats. The condition of adjacent habitats influences the ecosystem services provided by a habitat, for example, the services by corals and seagrass beds are influenced by the condition of the mangroves[5, 6] as many coral reef fish species migrate between coral reefs, seagrass beds, and mangroves.

Due to its position at the intersection of land and sea, the coastline and its ecosystems are impacted by both land-based and ocean-based industries, that include seafood, ports and transport, renewable energy and coastal tourism. These industries and the human development of the coastal areas are drastically impacting the coastline, as anthropogenic pressures in the marine environment deplete natural capital stocks and reduce their ability to provide ecosystem services. Some of these impacts include the release of pollutants into the water, costal development and erosion, sediment input, fishing and grazing. However, along with the impacts, the same industries depend on the resources provided by the coast.

The Blue Economy is increasingly recognized for its substantial contribution to global economies, indeed if it were to appear on a list of national economies by size, it would be 7th (in this case based on values of

[3] World Ocean Assessment, UN2016 https://www.un.org/regularprocess/content/first-world-ocean-assessment
[4] The State of World Fisheries and Aquaculture, 2020. http://www.fao.org/3/ca9229en/ca9229en.pdf
[5] Osborne, Chetwynd Carlos, Leandra Cho-Ricketts, and Jané Salazar. "The Relationship between Resilient Mangroves and Fish Populations in the Largest Marine Reserve in Belize: A Case for Conservation." *BioRxiv* (2019): 719757.
[6] Sheaves, Marcus. "Nature and consequences of biological connectivity in mangrove systems." *Marine Ecology Progress Series* 302 (2005): 293-305.

fishing, aquaculture, tourism, shipping, carbon sequestration and biotechnology; Blue economy initiative[7]). Despite the increasing reliance of the economy on the coastal systems, these areas often have poorly defined governance systems, often leading to a lack of understanding and undervaluing of the services provided. The connections between the land-based activities and the coastal ecosystems are therefore not fully accounted for and can lead to over-exploitation and long-term detrimental damage.

Decision makers across the world are increasingly recognizing the important role that coastal systems have on the well-being of their citizens and on economy performance, and are working to incorporate the coastal ecosystems into decision-making. Anthropogenic drivers, both indirect and direct, must be taken into account in the decision-making process, in order to drive the decisions that are beneficial to all the stakeholders and the habitats. While some decisions can be direct drivers of change, for example the prohibition of chlorofluorocarbons, more commonly decisions influence direct and indirect drivers, such as demographic changes, technological innovation, resource use, and land use. These decisions impact both the people and the surrounding ecosystems. Working towards creating sustainable green-blue economy is a challenge that must be met, and in order to do so, communication between the different industries, economies and countries must increase, as due to the interlinking nature of the region, no system can be isolated from the process.

Ridge to Reef

In an effort to evaluate the status of coastal resources, the International Resource Panel found that many land-based activities exert a negative pressure on coastal biotic resources and that the management regimes of land-based activities do not typically account for this pressure. This demonstrates the importance of taking a Ridge-to-Reef approach to resource management. Ridge-to-reef is an approach to account for connections between land and sea based on water basins that stretch from the mountains to the sea. In Grenada, a ridge to reef approach has helped to develop incentive schemes to encourage good practice for upland agriculture and livestock activities to reduce polluted run-off degrading coastal ecosystems (UN Environment, 2018). The ridge to reef approach is a wholistic approach that may offer important learning opportunities related to the governance of individual impact pathways.

Adapted from IRP (2020). Governing Coastal Resources: Implications for a Sustainable Blue Economy. Fletcher, S., Lu, Y., Alvarez, P., McOwen, C., Baninla, Y., Fet, A.M., He, G., Hellevik, C., Klimmek,

Decisions around coastal areas should empower stakeholders to drive positive decisions to an outcome that is beneficial to both nature and themselves, by recognizing and accounting for the value derived from the coastal ecosystems. While collaborative solutions and partnerships are emerging that will enable the cost of detrimental practices and impacts on the environment to be recognized, and improve the current and future use of coastal ecosystems. The pathway to do so involves engaging all

[7] Sustainable Ocean Economy, Innovation and Growth, 2030 Agenda and Development Cooperation; https://www.g20-insights.org/policy_briefs/sustainable-ocean-economy-innovation-growth-g20-initiative-7th-largest-economy-world/

stakeholders into the decision making process, allowing the outcome to be agreed stakeholders into the decision making process, allowing the outcome to be agreed and supported, which would ultimately drive impactful decisions to both nature and the stakeholders themselves.

Papua New Guinea Land-Sea Conversation Planning (Adams et al. 2017)

Papua New Guinea's waters are part of the 'Coral Triangle' which encompasses the area of the world with the highest known marine biological diversity. Land-sea planning allows the connection of terrestrial, coastal and marine habitats to ensure a collaborative and interconnected system between upstream and downstream conservation.

Large-scale agriculture and forestry are major industries in PNG, and the run-off from these industries causes significant impacts on coastal ecosystems. Sedimentation from logging and palm oil development is increasing, with subsequent degradation of the coastal and nearshore reefs. The link between the marine conservation and terrestrial priorities to identify areas of concern and run a new prioritization to avoid areas that are predicted to be degraded or at high risk.

The assessment was used to identify priority areas and engage local communities / landowners to develop viable management. The use of a land-sea assessment helped Papua New Guinea to achieve biodiversity conservation across the different habitats and sectors. This assessment demonstrates how looking at upstream land-based activities is a critical part of coastal resource management.

Adams, V.M., Tulloch, V.J. and Possingham, H.P., 2017. Land-sea conservation assessment for Papua New Guinea. *University of Queensland, Brisbane, Australia*, *10*.

1.2 On the wrong path

1.2.1 The invisibility of nature in decision-making

Weak governance, contradictory policies, and inappropriate incentives have resulted in unsustainable behaviors and inequitable outcomes in coastal areas. Decision makers – public and private, national and local – have too often implemented policies, regulations, initiatives and investments that lead to inequitable and unsustainable outcomes for communities and ecosystems such as declining coastal seafood stocks, loss of coral reef and other coastal habitats, and persistent poverty.

These problems persist for four reasons:

i. Because we tend to treat social, economic, and environmental objectives independently, drawing policy conclusions by looking at problems in silos rather than from a systems perspective;
   Because decision-makers make decisions to benefit their constituencies, clients, or stockholders, not for the global good which risks widening the gap between private incentives and social benefits;
ii. Because we tend to focus on short-run benefits (income) rather than long-run wellbeing (wealth); and

iii. Because the many dependencies between human activities and nature are economically invisible to decision makers.

The combination of these issues means that there is a lack of awareness of, or a failure to measure and acknowledge, sectoral and temporal tradeoffs between decisions.

These failures persist in part because decision makers do not see clearly and simply the tradeoffs between human activities and coastal ecosystems, between stakeholders, and between short-run benefits and long-run wellbeing. Basic economic metrics such as profit and gross domestic product do not represent the full costs and benefits of human activities and therefore do not send signals to economic actors to change their behavior. The full social and environmental impacts of decision options and their potential outcomes are economically invisible. Importantly in the context of TEEB for Coasts and its potential role, there is also a lack of clear guidance for measuring and evaluating ecosystem service supply and demand, and more generally, for balancing the wants and needs of current and future generations.

Analyzing anthropogenic activities is particularly complex in coastal areas because of the myriad of interrelationships between land and sea discussed in section 1.1. Evaluating the tradeoffs of a decision is inherently difficult because a single decision may impact multiple sectors, many different stakeholders, and a range of ecosystems and un-priced ecosystem services. Further, there is insufficient understanding of the cause-and-effect relationships between stocks of human, natural, and social capital and the flows of benefits and impacts. Decision makers are faced with the complexities in distinguishing between potential benefits (provision of services or supply) and realized benefits (people's needs or demand)[8]. One primary example of this is found in Belize, where the Belize government put a permanent stop to oil and gas activity to preserve the Belize Barrier reef[9]. The Belize Barrier Reef is a fragile ecosystem and designated world heritage sites and indicates the importance of putting people and the environment first, as well as preserving ecotourism for the communities.

The nature of the coastal systems means that they are located downstream of pollution and runoff, through river and low-land transfer, which means that the drivers could be occurring at quite a distance to where the impacts are being felt. This increases the complexity and the importance of developing a systems approach to the challenge. Many of the measurements are taken from the harvesting, such as fish stock decrease, rather than the inputs of upstream pollutants or land-use change.

Sustainability, most simply, requires acknowledging planetary limits. But acknowledging risks is not enough. Decision makers must negotiate a balance of economic, social and environmental interests, strike a balance between stakeholders and between generations. And to do that they must see the true costs of business-as-usual and the true benefits of compromise.

[8] From Kramer et al., 2019: "The relative proportion of nature's contribution along with people's needs, especially for the most vulnerable people, is a more useful metric than realized benefits alone when considering change across several variables at once (stressors, people, and nature) because they reveal where and when nature plays a key role in delivering benefits."

[9] Belize Bans Oil Activity to Protext its Barrier Reef, Capitals Coalition, 2018, https://capitalscoalition.org/belize-bans-oil-activity-to-protect-its-barrier-reef/

The Invisible Value of Nature (TEEB 2010)

Ecosystems and biodiversity underpin all of the economy, but the services and value are often unaccounted for, leaving nature as an invisible contributor. Without thoroughly understanding the value of nature, humans have be depleting and over-exploiting its resources without accounting for the affect this will have on the economy and the future wellbeing of the world.

The concepts of ecosystem services and natural capital can help us recognize the many benefits that nature provides. From an economic point of view, the flows of ecosystem services can be seen as the 'dividend' that society receives from natural capital. Maintaining stocks of natural capital allow the sustained provision of future flows of ecosystem services, and thereby help to ensure enduring human well-being. Sustaining these flows also requires a good understanding of how ecosystems function and provide services, and how they are likely to be affected by various pressures. Insights from the natural sciences are essential to understanding the links between biodiversity and the supply of ecosystem services, including ecosystem resilience.

Few ecosystem services have explicit prices or are traded in an open market. Those ecosystem services most likely to be priced in markets are the consumptive, direct use values of 'provisioning services,' such as crops or livestock, fish or water, which are directly consumed by people. Non-consumptive use values, such as recreation, or non-use values, which may include the spiritual or cultural importance of a landscape or species, have often been influential in decision making but these benefits are rarely valued in monetary terms. Some other ecosystem benefits, especially regulating services such as water purification, climate regulation (e.g. carbon sequestration), and pollination, have only recently begun to be assigned an economic value, referred to as indirect use values. Although the latter values, when calculated, commonly form the majority of the Total Economic Value of an ecosystem, they remain largely invisible in the day-to-day accounts of society.

A basic premise of The Economics of Ecosystems and Biodiversity is that, through a rigorous and transparent process of recognizing, demonstrating, and capturing the value of ecosystems and biodiversity, conservation of nature can become a central tenant of private and public decision-making. The demonstration of economic value, even if it does not result in specific measures that capture the value, can be an important aid in achieving more efficient use of natural resources. It can also highlight the costs of achieving environmental targets and help identify more efficient means of delivering ecosystem services. Valuation in these circumstances enables policy makers to address trade-offs in a rational manner, correcting the bias typical of much decision making today, which tends to favour private wealth and physical capital above public wealth and natural capital. The approach promoted by TEEB is based on work carried out by economists over several decades. Significant progress has been made in economic valuation, and the contribution of nature to human wellbeing is increasingly being recognize and accounted for in economic decisions.

Economic valuation cannot be taken into decisions in isolation, it must be used within conjunction with other social and economic factors, and economic valuation will not be helpful in all contexts, for example in indigenous communities that do not participate in an exchange-based economy. Further, economic assessment should be seen as a tool to guide biodiversity management, not as a precondition for taking action. However, the framework of economic analysis and decision making described in the TEEB reports, if widely implemented, could go a long way towards making pro-biodiversity investment the logical choice for a much wider range of actors in the future.

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

1.2.2 The effects of making decisions in the dark

Many coastal regions are suffering from the implicit trade-offs of decisions that failed to fully account for the value of nature, did not recognize the complexity of coastal systems, and failed to acknowledge the impacts of decisions upon future generations and stakeholders without a voice in the decision making process. In places where people are most dependent upon ecosystems and natural resources, nature's capacity to contribute to human wellbeing is declining (Chaplin-Kramer et al., 2019). Decisions are being made 'in the dark'. Connections between nature and human wellbeing are not always obvious,

obscuring the tradeoff between the two. As well as increasing physical health through increased water quality or increased nutritional resources, numerous studies are surfacing that suggest interaction with nature can improve mental health through increased happiness, ability to manage life tasks, and performance in educational settings[10]. Loss of natural capital, such as coastal habitats, can directly impact financial and produced capital, such as a decline in fish stocks or loss of flood-buffering habitats resulting in reduced fish catch and flood damage to homes and businesses, but the magnitude of the tradeoff between these natural and produced assets is often difficult to see and easy to ignore. In other cases, the trade-off is simply not recognized or included within the decision-making.

One example of where nature is playing a critical role in ecosystem stability is in California, where sea otters have been named the 'kelp forest guardians' due to their ability to control the population of purple sea urchins[11]. Sea Otters in the area were hunted close to extinction in the early 1900s, which led to the encroachment of purple sea urchins into the kelp forests. Sea urchins are detrimental to the health of kelp forest, as they reproduce quickly and destroy the roots of the kelp fronds. As the sea urchin population increase, the extend of kelp forest cover decreases, damaging its ability to serve as carbon sinks and habitats to other vital species. Since the ban on fur hunting, sea otter populations have increased, which serves as a mediation mechanism for the sea urchins and therefore the kelp forests are also beginning to recover[12]. Kelp forests have been shown to nurture diverse ecosystems and provide benefits such as increased abundances of fish species, which may also positively affect fisheries (Christie *et al*. (2009) *Mar Ecol Prog Ser,* **396**; Bertocci *et al*. (2016) *Journal of Applied Ecology* **52)**. The ability of sea otter populations to affect their health (including the carbon cycle and therefore climate) was overlooked, which led to the destruction of these key habitats. Only with the sea-urchin control and ongoing maintenance of sea otter populations, were kelp forest able to recover and become reinstated in their role in carbon capture and habitat protection.

[10] Bratman, G.N., Anderson, C.B., Berman, M.G., Cochran, B., De Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J.J., Hartig, T. and Kahn, P.H., 2019. Nature and mental health: An ecosystem service perspective. *Science advances*, *5*(7), p.eaax0903.

[11] Smith, J.G., Tomoleoni, J., Staedler, M., Lyon, S., Fujii, J. and Tinker, M.T., 2021. Behavioral responses across a mosaic of ecosystem states restructure a sea otter–urchin trophic cascade. *Proceedings of the National Academy of Sciences*, *118*(11).

[12] Leighton, D.L., Jones, L.G. and North, W.J., 1966, January. Ecological relationships between giant kelp and sea urchins in southern California. In *Proceedings of the Fifth International Seaweed Symposium, Halifax, August 25–28, 1965* (pp. 141-153). Pergamon.

Direct loss of natural resource stocks represent only the most obvious examples. Many connections between nature and economies are more complicated and difficult to see. Landfills are smelly, ugly places, but once pollution is carried out to sea and dips below the surface, it is out of sight and out of mind. Mines leave obvious scars upon the landscape, but we may only perceive the impacts of undersea mining through delayed secondary impacts such as siltation and poorer reproductive success of marine species. Not all ecosystem services are equally visible. We tend to trade less obvious regulating services for obvious, marketable provisioning services – for example, fish (Dasgupta, 2021) and there is a clear literature bias towards certain ecosystem services, for example towards carbon storage rather than genetic material or pest control. The trade-off of regulating services for provisioning services is unsustainable, and an example in the Dasgupta review shows how the two can be balances to mitigate the trade-off. (BOX Dasgupta Regulating Services example)

The invisible value of regulating services

Focusing on lower trophic level aquaculture, such as bivalves and seaweed increase the absorption of nutrients from the water, decreasing eutrophication of coastal waters and increasing the water quality and clarity (regulating services). This in turn increases the fishery catch, as it provides habitats for nutritious fish species and increasing the provisioning services provided by the area. By changing the focus of the aquaculture, the number of fish available for human consumption increased without having a negative impact on the environment.

Dasgupta, P., 2021. The Economics of Biodiversity: The Dasgupta review, pg. 412.

We also need to understand, if not value, supporting services. For example, the supporting value of forage fish that humans do not directly consume is often overlooked for the provisioning value of larger fishes (Konar et al., 2019). As feed to the fish humans catch and consume (and other species we enjoy experiencing in the wild e.g. whales, forage fishes serve a supporting service. Although their value is embedded in the final value of the harvested species, focusing only on the provisioning service obscures the fact that the value of the provisioning services is a function of the health of the supporting service. In other words, although the provisioning services has value, the supporting services makes value; without the forage fish, the fish for human consumption would quickly decline and be unable to provide the nutritional value to humans. We need to understand the natural system to avoid losing the final values that we are most interested in.

Tradeoffs also arise because of the overlapping nature of coastal activities. Unlike agricultural land, where a hectare of farmland is dedicated entirely to farming, a 'hectare' of ocean could be simultaneously used for tourism, shipping, fishing, and mining. Because these are global industries, regulation and enforcement is potentially more difficult. Monitoring, Control and Surveillance (MCS) is a key aspect of fishery control[13], but is a fundamental challenge in open oceans, where huge distances and limited communication and monitoring facilities make it nearly impossible to have full oversight of each and every interaction with the ocean. Further, because of rich natural resources found at the coast, natural transportation pathways between land masses, and desirable coastal climates, coastal areas are

[13] Cremers, K., Wright, G. and Rochette, J., 2020. Strengthening monitoring, control and surveillance of human activities in marine areas beyond national jurisdiction: Challenges and opportunities for an international legally binding instrument. *Marine Policy*, *122*, p.103976.

the world's most crowded spaces. Nearly 40% of the world's population lives within 100 kilometers of the ocean. In addition to the challenges posed by population density and competing interests, property rights and governance of the land-sea interface has forever been complicated. Because access to the ocean is difficult to control and the resources within it difficult to measure and monitor, fisheries easily become a Tragedy of the Commons. And because coastal economic activities overlap spatially (e.g. tourism, fishing, recreation, and transportation can occur on the same stretch of coast), monitoring and enforcement of coastal activities is more complicated than strictly land-based activities.

In these rich, crowded, but hidden spaces, tradeoffs between sectors are inevitable. There is no *a priori* reason for us to have a preference for fishing, mining, shipping, or tourism – we want all their services – but investing in one sector can lead to damages for another. For example, if the proposed Pebble Mine in Alaska is permitted, downstream siltation and pollution will damage one of the world's last thriving wild salmon runs, the Bristol Bay salmon fishery[14]. The commercial fishing industry, the sport fishing industry, the bears that eat the fish, and the tourists that come for both depend on the thriving reproduction cycle of this highly productive anadromous fishery. Mining activities will have cascading effects through the trophic levels of the estuary. Further down the supply chain, far from Bristol Bay, salmon consumers will suffer higher prices from smaller catches. The loss of jobs from the collapse of the tourism and fishery sectors in which local communities are employed could be detrimental to the local economy. However, conversely, the mine would provide jobs and supply incomes to the local communities.

Decision makers, elected officials, and business leaders need to consider all stakeholders and the tradeoffs between them. They also need to consider the long-term implications of business-as-usual compared to alternative scenarios. If tradeoffs are not made transparent, we cannot expect decision makers to make the right choices. However, in addition to being transparent and comprehensive, tradeoffs must be made clear and brief. The US Environmental Protection Agency's assessment of the potential environmental impacts of the proposed Pebble Mine at Bristol Bay Alaska includes 630 pages of potential impacts, probabilities, contingencies, and confounding factors. Without a clear summary and quantification of tradeoffs, decision makers may be paralyzed by such a breadth of potential impacts defeating the purpose of a comprehensive, inclusive assessment.

[14] Parker, G.Y., Raskin, F.M., Woody, C.A. and Trasky, L., 2008. Pebble mine: fish, minerals, and testing the limits of Alaska's large mine permitting process. *Alaska L. Rev.*, *25*, p.1.

Examples of making the value of nature visible (TEEB 2010)

Global fisheries underperform by US$ 50 billion annually
Competition between highly subsidized industrial fishing fleets coupled with poor regulation and weak enforcement of existing rules has led to over-exploitation of most commercially valuable fish stocks, reducing the income from global marine fisheries by US$ 50 billion annually, compared to a more sustainable fishing scenario (World Bank and FAO 2009).

The importance of coral reef ecosystem services
Although just covering 1.2% of the world's continent shelves, coral reefs are home to an estimated 1-3 million species, including more than a quarter of all marine fish species (Allsopp et al. 2009). Some 30 million people in coastal and island communities are totally reliant on reef-based resources as their primary means of food production, income and livelihood (Gomez et al. 1994, Wilkinson 2004).

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

1.3 A fairer path

1.3.1 Improving well-being and livelihoods

Over the past twenty-five years the international community has strengthened awareness and recognition of nature's many visible and invisible contributions to human wellbeing. Costanza et al. (1997) drew attention to the magnitude of nature's contribution to people when they estimated the direct and indirect global value of 17 ecosystem services to be roughly double global GDP, around US$33 trillion per year (Costanza et al., 1997). The Millennium Ecosystem Assessment (2005) assessed the consequences of ecosystem changes for human wellbeing, formalized the definition of ecosystem services, and provided economic evidence that failure to account for the value of ecosystem services in decision making could have catastrophic consequences. But states have been slow to act. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services was established in 2012 to advance the scientific assessment of nature's contributions to people and encourage the use of scientific assessment in policy making. Since 2010 The Economics of Ecosystems and Biodiversity (TEEB), an initiative of the UN Environment Program, has sought ways to recognize and value the full array of impacts and dependencies between human activities and natural capital, and capture those values in public and private decision making.

In 2015, the Sustainable Development Goals were released and integrated into the 2030 Sustainable Development Agenda. The SDG's were designed to cover "all areas of the human enterprise on Earth"[15], as well as covering the major environmental issues, that link directly to coastal and ocean wellbeing, highlighted by the specific SDG 14 - 'Life Below Water', which aims to "conserve and sustainably use the oceans, seas and marine resources for sustainable development". Since the development of the SDGs, the United Nations Ocean Conference in 2017 and the regular World Ocean Assessments[16] in 2015 and 2021, have all sought to set voluntary commitments and build capacity with issues surrounding SDG14,

[15] Le Blanc, D., 2015. Towards integration at last? The sustainable development goals as a network of targets. *Sustainable Development*, *23*(3), pp.176-187.
[16] Assessment, M., World Ocean Assessment II. *United Nations*.

in particular trade and the exploitation of living aquatic resources. Sustainable Ocean conferences and panels have been expanding, and new reports are constantly emerging, along with the expansion and implementation of new management frameworks.

The consultation process for TEEB for Coasts highlighted the need for a coastal assessment, in whatever capacity, as there is no longer time to wait for the perfect tool and data to become available. Current approaches to coastal ecosystem and natural capital management are simply not doing enough, driving the need for TEEB to provide a viable approach and introduction into evaluation of policies. Within Coastal frameworks, evaluation of policy is particularly valuable due to the number of choices and sectors involved in the decision making. In each area of the world, the relationship between the stakeholders and coast is going to be different, and therefore a tool that can be adapted and tailored to specific issues would be useful. Additionally, by bringing the four capitals approach into the coastal systems, decisions made are more likely to support equality and the environment by taking the long-term system into account, rather than any short-term gains.

The four-capitals approach recognizes the complexity of natural "assets", and also who the user of the capital asset will be. For example, pollination alone is not an ecosystem service because pollination occurs irrespective of human presence – it becomes a service when its 'used' by people and provides a service. The framework should recognize the difference between realized and potential ecosystem services – where potential services highlight the potential for increases in sustainable use of ecosystems. Whilst the four capitals approach is increasingly being applied to businesses, more communication and involvement in needed to encourage the use by other stakeholders.

Accounting for the value of natural capital in decision making is not a bitter pill that must be swallowed to prevent ecosystem degradation, it is an opportunity to reduce poverty and develop sustainable livelihoods. Because many coastal ecosystems have been degraded, restoration of coastal ecosystems could offer significant benefits. The FAO has estimated that the potential economic gain from reducing fishing harvests to an optimal level and restoring fish stocks is around US$ 50 billion per year. Along with this, mangroves and coral reefs could prevent billions of dollars in flooding damage, offering barriers to storm and wave surges. Currently, mangroves are estimated to prevent $65 billion in damage every year, which is worth significantly more than the timber value of the mangrove trees alone[17]. Coastal zones also offer new opportunities, such as renewable wind, tidal and wave energy, as well as more complex Ocean Thermal Energy Conversion, or marine-based biomass fuels[18].

Poor communities are typically the most directly dependent upon natural capital and the most at risk to environmental degradation and climate change. The OECD estimated that natural capital accounts for about 26% of total wealth in low-income countries, 13% of wealth in middle-income countries and only 2% of wealth in OECD countries (OECD, 2008). Additionally, fish provide 3.3 billion people with at least 20% of their average per capita intake of animal protein[19]. This trend appears to be increasing, especially

[17] Sathirathai, S., 1998. Economic valuation of mangroves and the roles of local communities in the conservation of natural resources: case study of Surat Thani, South of Thailand. *EEPSEA research report series/IDRC. Regional Office for Southeast and East Asia, Economy and Environment Program for Southeast Asia*.

[18] Arumova, E., Belyaeva, E., Bitarova, M. and Panaseykina, V., 2020, January. Green Economy as a Direction of Sustainable Development of Coastal Areas. In *5th International Conference on Economics, Management, Law and Education (EMLE 2019)* (pp. 192-197). Atlantis Press.

[19] State of the World Fisheries and Aquaculture, 2020. http://www.fao.org/state-of-fisheries-aquaculture/en/

among coastal communities, making it a vital nutrition source. Because poor populations rely most directly upon natural resources, accounting for and managing for nature's benefits has great potential to benefit the poor. Evaluating the ways nature contributes to livelihoods can reveal opportunities to transition this dependence on exploitation of natural capital to economies that use human and social capital to support sustainable livelihoods less at risk to environmental degradation. Modeling of ecosystem services, valuation of ecosystem services, natural capital accounting, and models of the relationships between natural, human, and social capital can reveal these opportunities to stakeholders.

"Private incentives and social imperatives inevitably differ, so a government's task is to put into practice policies that bring the two into alignment as close as possible."

Produced capital, human capital and natural capital all contribute to human society, and connections to nature have been attributed to better mental and physical wellbeing. The sum of the accounting values of society's capital goods is known as inclusive wealth, which links together wealth and wellbeing. Currently, market value of good does not include the social value, leaving a gap between profits and social wellbeing. The complexity of this task is huge, natural capital can be inputting into different projects to different extents and different ways, so a woodland in one area that benefits quality of life, will be up against many contending projects that may result in more profits or short-term economic benefits.

Dasgupta (2021).

1.3.2 Fulfilling the needs of future generations

The Millennium Ecosystem Assessment warned that by drawing down our natural capital we are borrowing from future generations. Decisions have been made to benefit the wellbeing and livelihoods of the current generation, not our grandchildren and grandchildren's grandchildren. This shortsightedness persists because the impacts of today's decisions on the wellbeing of 22nd and 23rd century communities is not easy to see. Future impacts are not easy to see because the policy assessment mechanisms are using the wrong metrics. They focus on measuring income, a flow, rather than intergenerational wealth, a stock.

The Dasgupta Review (2021) demonstrates that social well-being is maximized *if and only if* inclusive wealth is maximized, that is, the sum of the accounting value of produced capital, human capital, social capital, and natural capital (Dasgupta, 2021). Inclusive wealth is an inter-generational concept. If decisions are made only to grow annual income, without awareness of the implications to nature, future generations will likely suffer. Dasgupta explains that the link between wealth and well-being is *accounting prices*, that is, changes in the value of the stocks of capital. The benefits and costs decision makers are accustomed to seeing are *market prices*, which do not necessarily reflect the future impacts of losses from ecosystem degradation. Changing these measurement principles, from market prices to accounting prices, will reveal the risks and opportunities that today's decisions offer future generations.

Inclusive wealth is the dynamic version of income. It is the accounting value of an economy's stock of manufactured capital, human capital, and natural capital (hence the qualifier "inclusive"). (Inclusive Wealth Report, 2018).

Current economic measure, such as GDP and income, are a poor indication of well-being and wealth as a whole. There is a desperate need to change the measure of human well-being in order to adjust the environmental and social crisis's of today. The Inclusive Wealth Index has been developed to measure human progress whilst taking all stock of natural, human and physical capital.

1.4 Measuring what matters for a Sustainable Blue Economy

It was recognized at the first Global Conference on Blue Economy in Kenya (2019) that substantial change is necessary to transition from business-as-usual to a Sustainable Blue Economy. The Nairobi Statement of Intent on Advancing the Global Sustainable Blue Economy states that "*[the] survival of humanity, biodiversity and ecosystems depend on bold, innovative and collective vision and action"*[20]. In order to support countries in developing their vision and transformative pathways to a sustainable blue economy, UNEP is developing a Decision Support Framework. The aim is to drive forward collective action and generate transformative change in the governance of the ocean and coasts. The failures of decision making in coastal areas offer an opportunity. Shedding light on the complexity of coastal biomes and communities could lead to great gains. The TEEB for Coasts is one component of UNEP's efforts to make this change happen.

In December 2020, three TEEB for Coasts Roundtables were held, bringing together more than 50 experts from around the world, to discuss the proposed TEEB for Coasts Evaluation Framework and provide feedback on its utility. These reinforced the view that - in the same way that the metrics used to evaluate food systems were put under the spotlight by TEEB[21] - the metrics used to assess the performance and potential of the Blue Economy need to be advanced. We cannot hope to deliver a sustainable blue economy, if our measure of success remains focused on estimating the marine realm's contribution to GDP (the typical measure used to highlight the importance of the blue economy).

Whilst moving away from this will be complex – and many challenges were raised during the roundtables – there remained general agreement that there was a gap in terms of simple, adaptable guidance for measuring trade-offs between capitals and between stakeholders that will occur as a result of decision makers' actions. A dedicated framework aimed to catalyse this kind of analysis, tailored to coastal settings – the roundtables reported – would be a welcomed by those working in coastal ecosystem management.

[20] http://www.blueeconomyconference.go.ke/wp-content/uploads/2018/12/Nairobi-Statement-of-Intent-Advancing-Global-Sustainable-Blue-Economy.pdf

[21] Smarter metrics will help fix our food system (nature.com)

How could TEEB be used to understand coastal areas and issues?

2 MAKING THE INVISIBLE VISIBLE: What should be measured to improve decision making?

2.1 Visible and Invisible Impacts: Benefits, Harms, Ecosystem Services, and Externalities

How do the conditions of our community impact our daily lives? What do we worry and wonder about? What influences decision makers' decisions or what do we wish influenced their decisions? *Impacts* are the things that affect, positively or negatively, our wellbeing. Food security, housing, income, health, poverty, security, employment, and many other benefits and costs, threats and opportunities, constraints and freedoms influence our lives, livelihoods, and ultimately our happiness. But despite their importance, impacts are not always easy to measure. Impacts may or may not be reflected in markets or exchanges. Food, shelter, and incomes are important impacts that can be readily quantified, we typically witness and record their production and exchange. Many impacts involve exchanges or trades those transactions can, at least partially, reveal their value. But markets do not exist for many of nature's benefits, for example, mangroves perform many valuable benefits for coastal communities - they prevent the erosion of coastal areas, protect homes, farms, and businesses from storm surge, sequester carbon, and provide habitat for birds and fish. These *ecosystem services* are provided with no monetary 'cost' but they do have a value. Because these services are provided for free, their ecosystem services are not represented by financial exchanges and are consequentially invisible to many decision makers, but just the same these benefits can be measured and quantified. Furthermore, even when a monetary exchange occurs, the monetary exchanges may not accurately quantify magnitude of the benefits or the contribution to human wellbeing (see next section on economic valuation).

The Big Seven: Coastal Ecosystem Services in the South Pacific (MACBIO 2016)

Through a consultive process with regional experts and government representatives, the MACBIO project (Marine and Coastal Biodiversity Conservation in Pacific Island Countries), supported by the German Ministry of Environment (BMUB), identified seven key marine and coastal ecosystem services that contribute to human wellbeing and therefore deserve the attention of natural resources managers and decisions makers. Those ecosystem services are:

- Subsistence seafood
- Commercial seafood
- Minerals and aggregate
- Tourism and recreation
- Coastal protection
- Carbon sequestration
- Environmental research and education

Minerals and aggregate are extractive, non-renewable goods; once they are sold or used they will not regenerate naturally over a human lifetime. Subsistence and commercial food goods are also extractive resources, but they are naturally renewable under the right conditions. The distinction between renewable and non-renewable goods becomes very important when estimating the value of the resource over longer timescales and brings up the question of how to weight benefits to future generations, and the relationship between natural capital stocks and the flow of ecosystem services. Tourism, coastal protection, and research and education are generally non-extractive services provided by ecosystems.

Marine and coastal ecosystems support a number of other important ecosystem services, including provision of raw materials and important biological and chemical compounds, pollution remediation, oxygen generation, temperature regulation, primary production, and other regulating and supporting ecosystem services. Many of these services are difficult to quantify and value and are not addressed directly in this guidance manual. However, some of these regulating and supporting ecosystem functions contribute to the goods and services that are addressed and therefore their value is embedded in the value of the seven ecosystem services addressed in this guidance manual, in so much as they contribute to the provision of those services.

The contribution of ecosystems in building social capital is also recognised as a cultural ecosystem service (Chan et al., 2012). Social capital is broadly defined as the social relationships and cohesion between individuals and communities that encourage reciprocity and exchanges, and enable establishment of common rules, norms and sanctions. Ecosystems may play a role in building social capital by providing space and opportunities for social interaction and play a role in establishing and maintaining cultural identity. Calculating the value of these cultural ecosystem services requires complex surveying and statistical analysis, often in the form of stated preference valuation methods, which were beyond the scope of the MACBIO project.

Salcone J, L Brander, A Seidl (2016) Guidance manual on economic valuation of marine and coastal ecosystem services in the Pacific. Report to the MACBIO Project (GIZ, IUCN, SPREP): Suva, Fiji.

Impacts can also be negative, cause harms or increase risks. Pollution can impact human wellbeing directly, through acute health impacts, or indirectly, for example by reducing opportunities for food production or tourism. These secondary, indirect impacts may be hidden, particularly if the people who are causing the pollution do not experience the impact. *Externalities* refer to unintended impacts to a third party (not the producer or consumer) from an activity or exchange between a producer and consumer. For example, if a shipping company leaks diesel into a harbor and that pollutant reduces the oyster harvest, the shipping company may not know or care about the impact. The impact may be invisible, but it is real.

The contribution of nature to human wellbeing can be made visible using economic valuation of ecosystem services. Valuing market and non-market services in a common metric, a monetary value, can facilitate comparison of the tradeoffs between financial gains on one hand and welfare losses on the other. Without valuation, non-market ecosystem services are often mentioned, but then ignored.

Total Economic Value of Bermuda's Coral Reefs: A Summary (Sarkis et al. 2013)

The table below (15.6) shows the estimated value, in millions of US dollars, of a variety of ecosystem services provided by coral reef ecosystems in Bermuda. The average annual benefit provided by the coral reef ecosystem was estimated to be about $722 million. The authors estimated upper and lower bound values for each ecosystem service, which demonstrates the uncertainty of the economic analysis, yet the range of total annual benefit, from $488 million to $1.1 billion, demonstrates the enormous contribution these ecosystems have to the island. The mix of cultural, provisioning, and regulating services illustrate the importance of protecting these reefs from an ecological, social and economic perspective.

Table 15.6 Upper and lower bound estimates of the annual benefits of coral reefs in Bermuda (2007US$ million/year)

Ecosystem service	Lower bound	Average	Upper bound
Tourism	324.7	405.9	487.1
Coastal protection	133.9	265.9	531.8
Recreation & Cultural	17.2	36.5	66.0
Fishery	4.3	4.9	5.6
Amenity	5.5	6.8	8.2
Biodiversity research	2.1	2.3	2.5
Total annual economic value	**487.7**	**722.4**	**1,101.2**

The contribution of ecosystem services to this value are, in order of importance: (1) Tourism (56% of TEV), (2) Coastal Protection (37%), (3) Recreational and Cultural (5%), (4) Amenity (1%), (5) Fishery (0.7%), and (6) Research and Education (0.3%). The estimation of the various ecosystem service values involves a large number of assumptions that simplify the underlying dynamics and complexities. Therefore, lower and upper bound estimates are determined for each ecosystem service, recognizing the uncertainty surrounding the economic analysis. The basis for this range differs for each value category. Further study could allow for the reduction of uncertainties and thus the narrowing of the value range. N.B. the values are annual values, based on 2007 data and prices.

Impacts could be measured in quantitative units, qualitative descriptions, or as a monetary value. Estimating the value of impacts in a common unit, a monetary value, can make them easier to compare and make it easier for decision makers to see and understand the tradeoffs inherent in decision making. Table XX is an example of a system for categorizing metrics of flows and impacts. Impacts could be evaluated by sector (e.g. tourism, fishing, recreation, mining) or by nodes in a value chain as shown in Table XX.

Table 1: Metrics of flows and impacts could be measured in qualitative descriptions, quantitative units, or monetary value

	VALUE CHAIN			
	Primary Production / Extraction	**Manufacturing / Processing**	**Distribution / Marketing / Service**	**Consumption**
FLOWS / IMPACTS (Annual benefits/costs, in units or value)				
Provisioning goods / services				
Foods (wild subsistence and commercial seafoods; aquaculture; agriculture and livestock)				
Materials (oil, minerals and aggregate)				
Income (jobs)				
Profit (businesses)				
Tax revenue (government)				
Transportation				
Produced inputs				
Energy (fuel, electricity)				
Materials (fertilizer, pesticides, fish feed)				
Infrastructure				
Ecosystem services				
Coastal protection				
Erosion / sedimentation control				
Carbon sequestration				
Biodiversity				
Environmental research and education				
Tourism and recreation				
Residuals				
Pollution (suspended solids, nitrogen, phosphorus)				
Solid waste				
GHG Emissions				

2.1.1 Common metrics for measuring impacts: Valuing costs, benefits and externalities in monetary terms

Value, in economics, refers to the contribution something makes to human wellbeing or happiness. Value is revealed by human preferences and decisions. If someone has the choice between coffee and tea, and they choose tea, we can presume that at that moment for that individual tea has greater value. Similarly, if someone has the choice between choosing lobster or steak for dinner, and they choose lobster, we can presume they value lobster greater than steak. What people must give up, trade or pay for a choice provides more information. If someone chooses to take a bus 30 minutes to swim in the sea instead of go on a run from home, we see that the value of the swim compared to the run outweighs the cost of travel to get there.

A price is not an economic value, but it does provide useful information. Prices and monetary exchanges are indicators or data points for measuring value. If the lobster costs $25 and the steak $15, we have

even more certainty that the individual who chooses lobster values lobster more than steak. This does not mean the value of a lobster is $25 and 300 grams of a cow is $15, but it does allow us to rank them relative to each other for the individuals that make a choice between them. Across millions of exchanges made daily by millions of people, monetary exchanges paint a picture of what people value.

All of this is to say that monetary valuation does not 'put a price on nature', it reveals human preferences. Monetary value does not necessarily imply a use or exchange, nor does the term Natural Capital imply any manner of integration or substitution with financial capital markets. People can value things even if they never use or experience them, revealed for example when people donate to protect wildlife in sub-Saharan Africa with no expectation they will ever visit and see these wildlife. Recreation, cultural and spiritual practices all provide welfare value to humans, and often there is no monetary exchange. To estimate their monetary value, economists look for data that demonstrates what people give up (or are willing to give up) or protect those things.

Monetary valuation is ranking and quantifying human preferences, not only accounting for exchanges or value in use. Total Economic Value includes both exchange value (sometimes called instrumental value) and welfare value. While spiritual, cultural, and recreational value all contribute to human welfare, there may never be a market or an exchange for these things. This means that spiritual, cultural, and other non-use values are more difficult to translate into monetary units, but they are still included in the rubric of economic value. A primary purpose of valuation is facilitating commensurate comparison of things that are important to human wellbeing. Sometimes not enough information is available to accurately estimate their economic value, but we may still be able to rank the value people have for these things and this ranking may offer a useful metric for decision makers.

The Dasgupta Review advocates attempting to estimate these accounting or shadow prices which reflect the true value of goods, services or assets to society, as an important step toward correcting the path of our economies and making sure that they no longer ignore the values of nature capital, and recognize humanity's dependence on nature. The Review reflects that even though calculating shadow prices is difficult and the values disputable, it is better that differences of understanding are aired rather than permitting the status quo – allocating a value of zero to nature capital. Figure 1 illustrates approaches for estimating the value of natural capital and ecosystem services.

2.1.2 Intrinsic Value

Humans may value species or ecosystems for their beauty, wonder, or spiritual significance, and in this way the existence of the species or the ecosystem is an ecosystem service (Batavia & Nelson, 2017). Spiritual values, cultural values, and option values may be difficult to quantify because they are often not reflected by monetary transactions, but whether or not they can or should be quantified they still represent anthropogenic value. The only non-human form of value is intrinsic value[22]. Intrinsic value has no relationship to human opinions and preferences and therefore lies outside the realm of economics. Many environmental philosophers and animal rights advocates such as Peter Singer have argued that all species and organisms have value unto themselves, have a right to exist, and therefore it is our responsibility to protect that right. Decision makers may wish to consider intrinsic value in their

[22] Sandler, R. (2012) Intrinsic Value, Ecology, and Conservation. *Nature Education Knowledge* 3(10):4

decisions[23],[24]. Because intrinsic value cannot be quantified, the benefits cannot be measured against the costs or tradeoffs that society may incur because intrinsic value has been prioritized, however, this does not mean that intrinsic value should not be considered. As the economy is embedded within nature, there is a strong anthropocentric reason to protect it, if it is also sacred, with an intrinsic value – it is even more deserving of protection[25].

Intrinsic value is the value that an entity has in itself, for what it is, or as an end. If something has objective intrinsic value, it has properties or features in virture of which it is valuable, independent of anyone's attitudes or judgements. If species and ecosystems have objective intrinsic value, then their value is discovered by human valuers, in is not created by them. (Sandler, 2012).

Intrinsic values were applied in a Life Framework approach in West Coast of Scotland and the South West of England, where a number of hypothetical social-ecological scenarios were developed on marine ecosystems and their services. The results showed that 'the different stakeholder groups all valued the marine environment in multiple ways, each of which spanned multiple Life Frames of value'. The frameworks ability to cross different interests and incorporate intrinsic and environmental values makes it very useful in environmental governance. It allows the interests of non-human stakeholders to be incorporated into decisions along with those of the human stakeholders. As the emphasis on nature as a provider of ecosystem services and contributor to human well-being increase, the importance of intrinsic values in decision-making also increases (O'Connor and Kenter, 2019).

2.1.3 The challenges and limitations of monetary valuation

Whilst monetary values can be useful, they also come with caveats. They can be difficult to derive due to gaps in data and knowledge, as they require both the capacity to quantitatively measure changes in stocks and flows in units which can be connect to economic values, and having access to monetary values for such benefits.

Another issue may be understanding the meaning of monetary values and what they capture. Different valuation methods capture different aspects of the impact of a good or service on human welfare, and some may even only capture the cost of securing a benefit (not the value of the benefit at all). It is also important to reflect that monetary values should be marginal values, that relate to the changes being explored. Looking at total or average values is less useful, as these are not subject to a potential tradeoff, so may be misleading. Where non-marginal changes occur, monetary values are also difficult to use as, for example, if a tipping point is reached and an ecosystem changes state, the unit values of benefits may be very different before and after the change – estimating this would be very difficult.

The comparison of stocks, flows, and impacts can be qualitative or quantitative, and in biophysical terms or monetary value. Although TEEB encourages and supports countries to use economic valuation, the

[23] O'Connor, S., Kenter, J.O. Making intrinsic values work; integrating intrinsic values of the more-than-human world through the Life Framework of Values. Sustain Sci 14, 1247–1265 (2019). https://doi.org/10.1007/s11625-019-00715-7

[24] Batavia, C., & Nelson, M.P. (2017). For goodness sake! What is intrinsic value and why should we care? *Biological Conservation,* 209, 366-376.

[25] This logic is reflected in the Dasgupta Review of the Economics of Biodiversity

Framework will recommend valuation only if desired by stakeholders and when it is methodologically appropriate to answer the given policy question.

Using expert opinions to compliment ecosystem service valuation of mangroves (Mukherjee et al 2014)

Because not all ecosystem services can be easily quantified in monetary units, researchers have been experimenting with ways to rank the value of services. Mukherjee et al. (2014) used an expert-based participatory approach called the 'Delphi technique' to rank ecosystem services provided by mangroves, at a global scale, using the CICES framework to characterize services. The 'experts' in their study consisted of "established mangrove ecologists, mangrove managers and on-ground restoration biologists who were/are involved in mangrove research and management for at least 8 years." They compare the results of their ranking approach with monetary valuations taken from environmental economics literature.

"The experts identified 16 ecosystem service categories, six of which are not adequately represented in the literature. The role of mangroves in fisheries, coastal protection, protection from sedimentation and provisioning for wood and timber were identified to be the top three ES of mangrove ecosystems (Fig 2). Three of these ES fall under the category of regulation and maintenance services according to CICES, with ''fisheries'' being spread over both provisioning (nutrition) and regulation and maintenance (nursery function). Mangrove ecosystems were also identified to be important environmental risk indicators and carbon sequesters. In the context of climate change, the emphasis on coastal protection and protection from sedimentation are particularly important, given the location of mangroves close to the coast and the rapid decline of mangrove area in the past few decades."

The expert based valuation provides some different value rankings than the economic valuation (Fig 3), indicating that the scope of valuation of ecosystem services needs to be broadened. Most notable is the complete absence of values for some services. "*Acknowledging this diversity in different valuation approaches, and developing methodological frameworks that foster the pluralism of values in ecosystem services research, are crucial for maintaining the credibility of ecosystem services valuation."*

Mukherjee N, Sutherland WJ, Dicks L, Huge´ J, Koedam N, et al. (2014) Ecosystem Service Valuations of Mangrove Ecosystems to Inform Decision Making and Future Valuation Exercises. PLoS ONE 9(9): e107706. doi:10.1371/journal.pone.0107706

Cont.

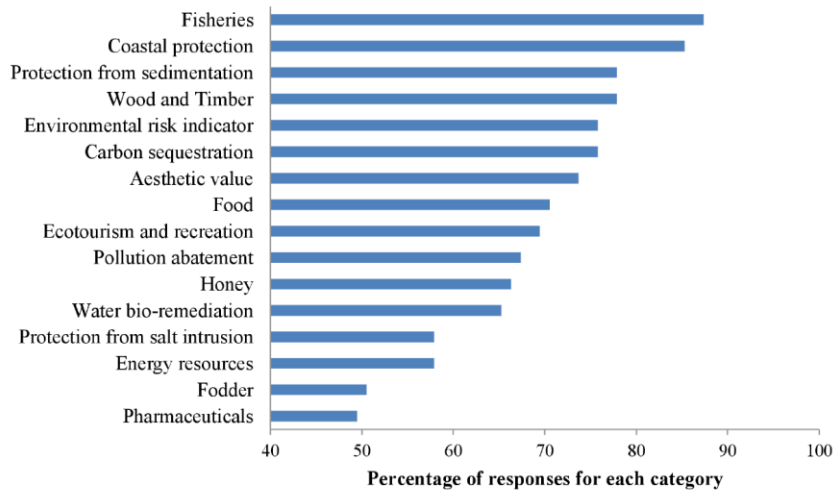


Figure 2. Ranking of the ecosystem service categories of mangroves based on the scores given by the experts in the Delphi technique.

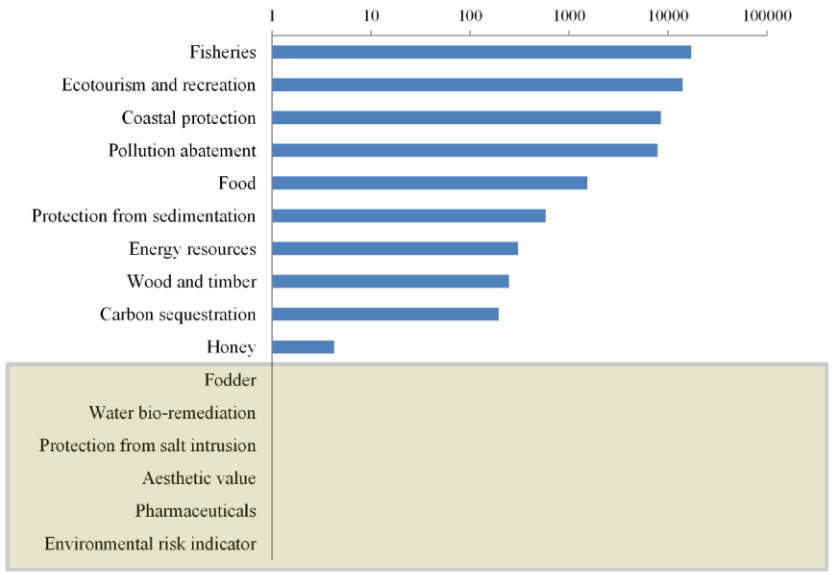


Figure 3. Average economic values (log scale) of the different ecosystem services noted in literature standardized for 2007 Int$/ ha*yr. The five ecosystem services for which no economic values were found, are highlighted in the shaded box.

2.2 Systems approach (Life-cycle assessment, cradle to grave, or value chain)

The fundamental ecological principle of connectedness is well illustrated by the John Muir quote, "*When we try to pick out anything by itself, we find it hitched to everything else in the Universe.*" Systems thinking can help understand how the various elements of life are connected and help reveal the invisible dependencies which are present. One of the challenges faced currently is that economics activities are often considered separately from other systems. However, it is not possible for economics to independent of the people who created it, and the world in which they live. The socio-ecological

system is made up of two connected elements, 1) human society and the economy; and 2) the natural environment. These two elements interact with each other through the exchange of energy, resources and waste. Generally, the human element consumes and exports waste to the natural environment. Humans are totally dependent on the existence of the natural environment, taking in natural resources and benefits of nature, also described as ecosystem services. Society exports waste in the form of pollution back to the natural environment. This relationship is therefore not equal. While humans need materials from nature, the converse is not the case, the environment is not dependent on the existence of humans and in many situations suffers the consequences of excess waste.

The TEEB four capitals approach adds more detail to the two-part system described above and provides a method to approach problems with a systems lens. The advantage of thinking using the four capitals approach is that it helps to consider the whole system rather than just focusing on small elements of it. TEEB approaches problems by considering human, social, produced and natural capital, and the flows between these. See section 2.3 for a detailed description of the four capitals. The TEEB framework uses a value chain approach. By considering the full value chain of a product to trace the inputs from the environment all the way through to the waste that is returned back to it, and consider all aspects of value along the way, it is possible to understand effects on the wider system. Considering the changes in the four capitals as you move through a value chain allows the wider system to be considered and avoids just looking at the effects within only the economy.

The systems lens is particularly helpful when considering economic problems. Traditionally, society has considered economics 'outside' of the earths system. However, it is a construct of a human society, and therefore the health and wellbeing of society and nature will affect the economy. The finiteness of nature places limit on the extent to which GDP can be imagined to grow. It also places boundaries on the extent to which inclusive wealth can grow[26].

In addition to the fact that economies are embedded within nature, there is an additional consideration in the context of the ability to substitute one type of capital for another. For example, we use nature or 'natural capital' as a mechanism to clean waste from our water. To a limited extent, we can built water treatment plants and substitute our innovation and technology to substitute the benefits that nature provides. However, there is a limit to the quantity of nature that can be substituted for man-made solutions before it effects the wider system. For example, the conversion of the Amazon rainforest for agricultural production, which recent analysis suggests in now leading to changes in rainfall patterns and decreases in agricultural revenues[27].

What is capital based thinking?

2.3 Four Capitals: A focus on wealth not income

This is important, as income, or consumption levels can be increased by consuming wealth – for example by fishing a fish stock beyond its capacity to regenerate. This raises income in the short term, but at the expense of lower fish catches in the future. A useful analogy for why wealth is important is to think about a bank account, if we (and future generations) want live off the money on that account and have consistent living standards, we must live off the interest on the lump sum in the account. If we want to

[26] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/957292/Dasgupta_Review_-_Abridged_Version.pdf

[27] Deforestation reduces rainfall and agricultural revenues in the Brazilian Amazon | Nature Communications

improve our living standard sustainably we must increase the lump sum. The same is true for countries, especially if the population is growing, as the capital stock per capita must rise for increases in well being to be delivered and sustained in the long term. In this context it is crucial to measure all capital stocks, as to exclude elements of the capital stock risks neglecting it, and allowing the stock to decline unrecognized, and meaning that we inadvertently put at risk the wellbeing of future generations. This problem has been historically revealed with respect to natural capital as shown in the figure below.

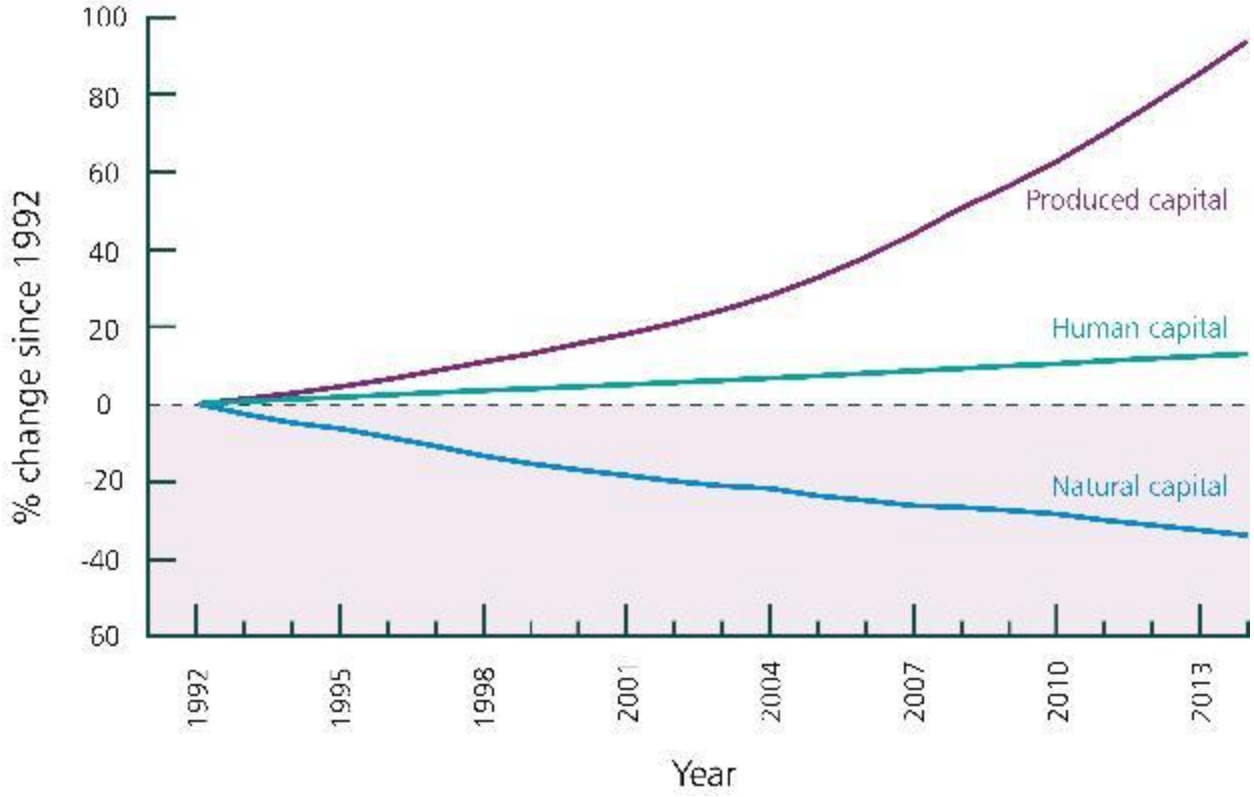


Figure 1 relative changes in capital stocks since 1992 [Source: Dasgupta Review]

There are two reasons to use a capitals approach to assessing scenarios. First, capital stocks and accounting prices reflect intergenerational wellbeing, as explained above. Second, all outcomes and impacts, positive and negative, can be traced back to changes in the four capitals. Conversely, a change to these capitals often (but not always) results in impacts to human wellbeing. As illustrated in Figure XX, Capitals can grow or shrink, they can contribute to each other, and in some instances they can substitute for one another. For example, human ingenuity has developed electric cars and ships that can be powered by renewable solar and wind energy. This may reduce the need for off-shore drilling for oil and reduce pollution from leaking ships and transportation pipelines. The reduced pollution and coastal disturbance could in turn benefit fisheries and tourism. In this example human capital was used to substitute for and restore natural capital. A governance system (social capital) may be needed to support and incentivize this transition.

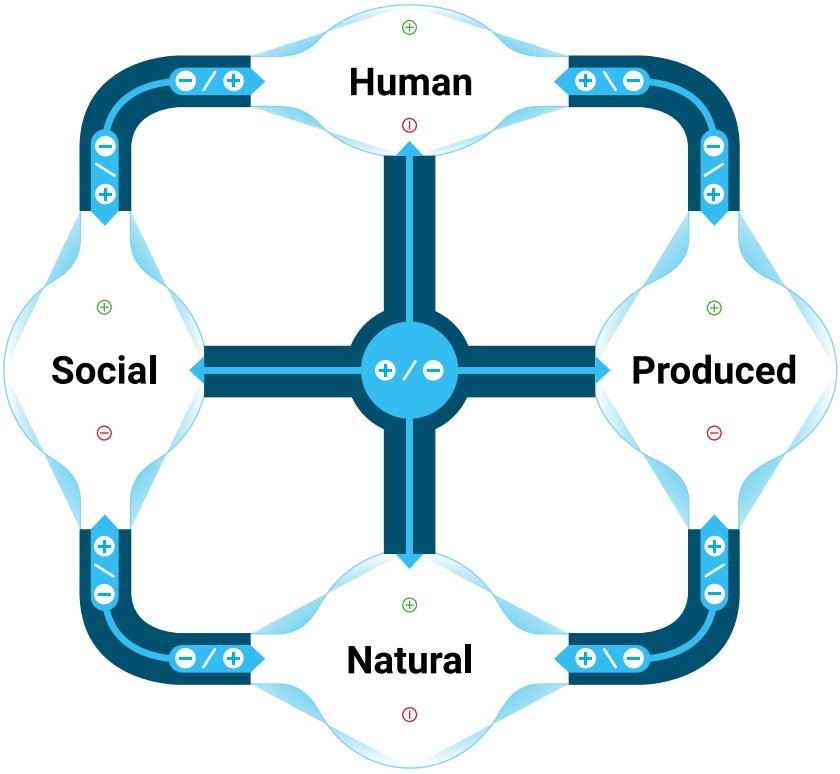


Figure 2 Capitals can grow or shrink, compliment and to a limited degree substitute

i. Natural Capital

Natural capital refers to "the limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services" (TEEB 2010). For measurement purposes it incorporates the "naturally occurring living and non-living components of the Earth, that in combination constitute the biophysical environment" (UN 2012). This includes timber, fish and other biological resources, land and soil resources, mineral and energy resources, and all ecosystem types (forests, wetlands, agricultural areas, coastal and marine, etc.). Natural capital can degraded and depleted until it no longer provides benefits to society, but unlike produced capital, it can naturally regenerate.

ii. Human Capital

Human capital refers to "the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (Healy and Côté 2001). Human capital supplies inputs to the production of goods and services as well as the production of household services such as raising children and managing a household. Human capital will increase through growth in the number of people, improvements in their health, and improvements in their skills, experience and education, including traditional and indigenous knowledge. Human capital can also depreciate if skills and experience decline, or through deterioration in human health conditions.

iii. Social Capital

Social capital refers to "networks together with shared norms, values and understandings that facilitate cooperation within or among groups" (Healy and Côté 2001). Social capital may be reflected in both formal and informal governance and can be considered more generally the "glue" that binds individuals in communities. Social capital often "enables" the production and allocation of other forms of capital (UNUIHDP and UNEP 2014).

iv. Produced Capital

Produced capital incorporates all manufactured capital such as buildings, machines and equipment, physical infrastructure (roads, water systems), and the knowledge and intellectual capital embedded in, for example, software, patents, brands, etc. Produced capital encompasses all types of financial capital, excepting that the administration of financial capital depends upon social capital.

Metrics for measuring the four capitals will vary, but generally will include a description or characterization (type), a measure of extent, and a measure of condition. It may be possible, and desirable to decision makers, to estimate the asset value of each capital stock. The asset value represents the net present value of future flows of benefits that are available as a function of the capital's extent and condition. The table below provides an example of a system for categorizing capital metrics.

Table 2: Accounting for capital stocks, by sector

	SECTOR / USER / STAKEHOLDER			
	Fisheries	**Tourism**	**Energy / Mining**	**Residential / Recreation**
STOCKS / OUTCOMES (Change in capital type, extent, condition)				
Natural capital				
Ecosystems				
Coral reef				
Beach				
Delta / Estuary				
Mangrove				
Kelp, seaweed, seagrass				
Habitat (connectivity)				
Water (quality, temp., quantity (freshwater)				
Biodiversity (range-rarity, abundance)				
Stored carbon				
Produced capital				
Infrastructure				
Research and development				
Technology, equipment				
Financial capital				
Human capital				
Education, skills				
Workforce				
Health (diet, mental health, recreation)				
Social Capital				
Rights and empowerment				
Social cooperation and governance				
Institutions and agencies				
Rule of law (e.g. jurisdiction)				

Natural Capital Accounting for the Great Barrier Reef

The System of Environmental Economic Accounts - Ecosystem Accounts (SEEA-EA) is a statistical standard adopted by the UN Statistical Commission. SEEA-EA is an integrated framework for organizing data about natural capital, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity. The Australian Bureau of Statistics has created accounts to track the extent and condition of coastal natural capital of the Great Barrier Reef. The SEEA-EA defines ecosystem assets as '*spatial areas containing a combination of biotic and abiotic components and other characteristics that function together*' (para 4.1 SEEA-EA). Following the standard, ecosystem assets are measured in terms of extent and condition, as well as the expected flows ecosystem services.

"The Great Barrier Reef (GBR) provides economic and community benefits in the form of tourism, employment, cultural services (tourism and participation in cultural activities) and provisioning services (aquaculture, fish, etc.) Marine condition is likely to impact the future economic and community benefits provided by this unique ecosystem."

Summary of Marine Condition Accounts

"Following the heavy rainfall events of 2010-11, marine ecosystems showed an overall decline in condition but started to show signs of recovery from 2012-13 to 2014-15. Marine condition is heavily influenced by cyclones, severe weather events, rainfall and pollutant run-off.

- Water quality scores in the GBR Region and all six NRM regions declined between 2007-08 and 2010-11, after large storm and flooding events, and then fluctuated through to 2014-15. There were five Category 5 cyclones in the region between 2006 and 2015, following a period from 1970 until 2006 where there were no Category 5 cyclones recorded, highlighting the increase in frequency and severity of storms in recent years.
- From 2005-06 to 2014-15, the coral condition decreased, based on coral condition scores presented in the Great Barrier Reef Report Card 2015. All NRM regions reported an increase from 2013-14 to 2014-15, following large decreases after the 2010-11 flooding events. Coral condition change is a balance between disturbance events and regrowth rates. Repeated disturbances such as the 2016 and 2017 bleaching events and increased cyclone events are likely to both directly damage and reduce coral condition and to impact on regrowth rates. It should be noted that these last two bleaching events occurred outside the reference period for this publication, with respect to coral condition scores, and the impact of these will be reflected in future updates.
- Seagrass decline is thought to be due to a range of impacts such as deposition of nutrients and sediments from agriculture, and marine-based activities such as dredging and anchor damage. In the last few years, the trending decline of seagrass meadows appears to have slowed and in some cases reversed, in part due to decreased rainfall leading to lower volumes of discharge and river loads.
- The abundance of selected fish species has remained relatively stable across the majority of NRM region marine extensions between 2001 and 2017. The exception is the Burnett Mary NRM region, which experienced an overall decrease of 11% in the number of fish species recorded between 2001 and 2017."

2.4 The connections between capitals and impacts: Flows of outputs, inputs, ecosystem

Many blue economy sectors rely heavily on marine and coastal natural capital and the ecosystem services they provide, such as fisheries and coastal tourism. Any change to the condition of the habitat and the ecosystem service can have pose significant operational risk to the sectors. The ecosystem service provision can be influenced by the biodiversity of the area, the species and composition of the biodiversity community, and where degradation has caused the extinction of plants and animals. This can also include there the number of individuals of a species is reduced to the point that they are unable to contribute to the service provision, and therefore are 'functionally extinct'. The loss of species in a local area can drastically reduce the regulation and provision services, and in extreme cases, cause the loss of spiritual and cultural value to a community.

The relationship between the coastal natural capital and fisheries was highlighted by a study conducted in Belize[28] where the importance of a healthy and connected mangrove habitat as a nursery habitat for species found in other habitats, such as coral reefs and seagrass meadows. Fish biomass can be substantially higher in the habitats surrounding mangroves (such as coral reefs) due to the provision of nursery grounds by mangroves and increased ability of juvenile fish species to move between habitats. The conservation of mangroves has been shown to enable recovery of fish population in nearby coral reefs, even if the reefs themselves are degraded[29]. The presence of a mangrove nursery can reduce the vulnerability of coral reef fish stocks to ongoing and future degradation, which protects the fish biomass and population for use as food and nutrition for both local communities and industry.

Coastal habitats are of course important beyond their value to fisheries. Other services provided by the coastal habitats include:

- Buffering and attenuation of mass movement;
- Wild animals (terrestrial and aquatic) used for nutritional purposes;
- Control of erosion rates;
- Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants and animals;
- Hydrological cycle and water flow regulation (including flood control, and coastal protection);
- Maintaining nursery population and habitats (including gene pool protection);

The above list is non-exhaustive and does not encompass all of the services provided, but displays the variety of connections between habitats and ecosystem services. These services in turn provide support to a wide range of sectors, both coastal and beyond. These connections, from habitat to service to economic sector are illustrated in the diagram below. Importantly, it shows the potential for a single habitat to produce a range of flows, and provide inputs to a number of sector – revealing an important the interconnected nature of economic activity in the coastal zone; that several sectors can rely on the same underpinning natural capital stock. .

[28] Rogers, Alice, and Peter J. Mumby. "Mangroves reduce the vulnerability of coral reef fisheries to habitat degradation." *PLoS biology* 17.11 (2019): e3000510.
[29] Rogers, Alice, and Peter J. Mumby. "Mangroves reduce the vulnerability of coral reef fisheries to habitat degradation." *PLoS biology* 17.11 (2019): e3000510.

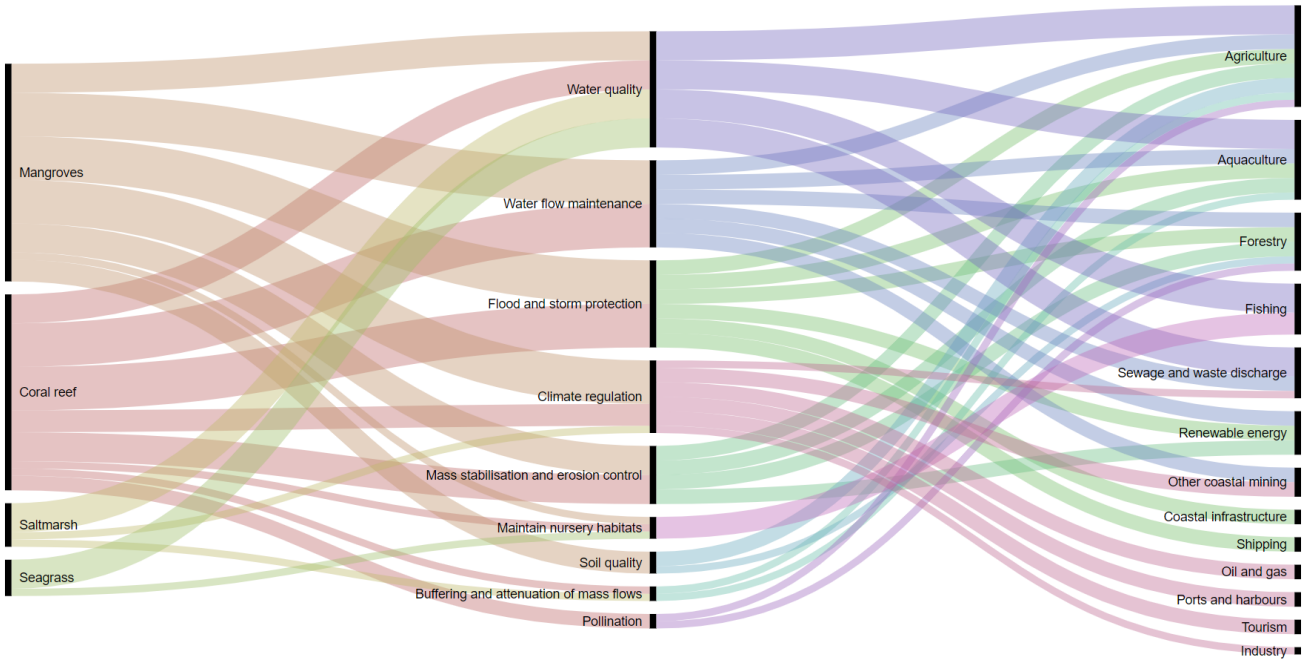


Figure 3 Coastal habitats, their services and the sectors which benefit from them (This is taken from a forthcoming research paper so should not be reproduced beyond UNEP at this stage)

Flows describe what is happening. They are the link between the capitals and impacts. All flows result in an outcome, and many of those outcomes become impacts to humans. TEEB categorizes four types of flows: inputs, outputs, ecosystem services and residuals. Flows can be *outputs* or yields provided by capital assets. Flows could also be measured as *inputs* where the output from one capital is an input to another capital. Any measurable change to a capital stock is a flow, but unlike money flowing into or out of a savings account, flows from natural, human, and social capital do not necessarily change the capital stock. However, both the extent (quantity) and the condition (quality) of the capital stock influences flows. The *functions* provided by ecosystems, such as nutrient cycles, food and biomass production, and climate are flows provided by stocks of natural capital. Unintended outputs, such as greenhouse gas emissions or solid waste are called *residuals*. The variety of types of flows and the complexity of relationships between stocks and flows make articulation and measurement challenging.

Impacts are distinguished from outcomes because all flows may produce an observable, measurable outcome, but not all outcomes result in impacts to humans. For example, sand mining in an estuary may generate a measurable increase in dissolved sediment levels in nearby waterways (an outcome), but if there are no communities nearby to notice the increased sediment it may not have a measurable impact (to humans although it may have an ecosystem impact). Unlike the produced capital economy, the supply of an ecosystem service from natural capital does not correspond to demand for that service. Increased sediment may reduce fishery productivity or diver visibility, but this outcome is only an impact if people fish or dive in this area.

The most visible and easy to measure flow is money because humans take very good care measuring exchanges and rates of exchange. Flows of wages, for example measure a relationship between labour

(human capital) and produced capital or social capital. Wages could also measure a flow from natural capital to human capital. But many inputs and outputs from human-nature relationships are not recorded in as much detail as money. For example, the function of shade from trees providing lower temperatures to a children's park is not captured by any direct monetary exchange, but it is a measurable flow. And, much in the same way that a monetary exchange may not accurately measure the magnitude of impact on human wellbeing, monetary exchanges may not accurately quantify the magnitude of flows between capital stocks.

Take for example the use of fertilizer on a field near a coastal area. We can measure the amount of fertilizer applied and how much it cost the farmer. And we can typically assume that the amount of benefit to crop production in the season it is applied is greater than the cost of the fertilizer, or a farmer would not buy it and apply it. But this monetary exchange does not measure all impacts from the flow of fertilizer from its source to its final resting place because, for example, residual fertilizer that ends up in estuaries and the ocean is not typically part of the financial comparison of input costs to output benefits. This residual may exert lasting damage to natural capital, such as through dead zones affecting fish stocks, resulting in another stream of flows, outcomes, and impacts. Thus the Framework shall recommend biophysical and descriptive accounts of flows.

"*These stock–service–benefit relationships are also strongly interdependent; for example, the condition of a woodland for recreation may also affect its suitability for rare species conservation. These spatial interdependencies extend to include off-site impacts and feed- backs over time, that are often omitted from the decision-making process. There needs to be a move away from traditional, single objective approaches towards the management of ecosystems for multiple functions and services for example avoiding the subsidy of terrestrial food systems which generate pollution compromising the potential for marine food production*." (Bateman & Mace, 2020)

The figure below attempts to capture important elements of the TEEB for Coasts approach, recognizing the need to understand how capital stocks interact and provide flows which support economic activity, and that economic activity has feedback effects which can influence the state of the overall capital stock. Only by examining how scenarios change this system as a whole can we assess the outcomes different choices at a societal level.

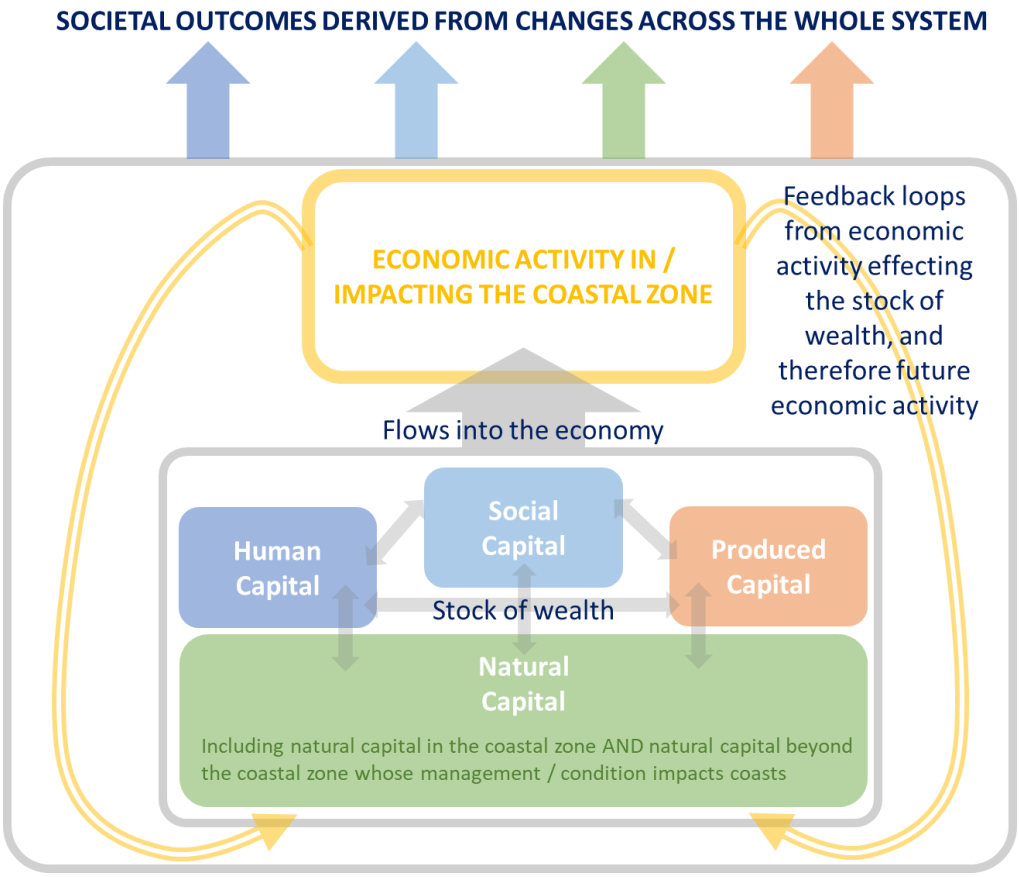


Figure 4 Interacting stocks, flows and feedbacks from economic activities influence outcomes for society

2.5 Opportunities and challenges

In adapting the stock-flow-outcome-impact approach to the coastal space, there remain both opportunities and challenges. Participants in the TEEB for Coasts roundtable identified a number of these that may relate to the proposed evaluation framework. Regarding challenges, there will firstly be difficulties in terms of navigating the balance between scope and depth of the analyses, as integrated perspectives (i.e. breaking down siloes) can generate large amounts of complexity. This is particularly true when scaling up the TEEB approach from value chains to entire systems. There may also be challenges around data, particularly variation in availability, type, and quality (including uncertainty). This may additionally exacerbate existing difficulties in threshold and 'tipping point' identification. Issues around substitutability may arise surrounding both its potential and limitations, and it will need to be carefully understood. Boundary identification and delineation will also likely be a major challenge, including accounting for impacts from outside the boundary once it is defined. Finally, other potential issues may include effectively engaging with such a wide range of stakeholders; dealing with conflicts, competing claims, and tradeoffs (and understanding how these may change over time); and scalability across local through to national contexts.

Despite these obstacles there remain exciting opportunities for TEEB for Coasts, such as governments looking to implement Sustainable Development Goals commitments; a proven record in assisting mitigate stakeholder conflicts (e.g. value mapping in the Caribbean); and interest from the private sector. The difficulties outlined will not prevent the development of TEEB for Coasts, but instead

highlight the ground-breaking nature and novelty of the framework. Key questions that will be considered in the continued development will include how to break down siloes and simplify a complex scope; how to tackle data variation, including where important elements cannot be measured; and how to deal with substitutability.

3 Using a capitals-based systems approach to decisions making

We propose that a capital's- based coastal evaluation framework be designed to guide comparison of Business-as-Usual to alternative scenarios. This TEEB for Coasts Evaluation Framework could be applied to assess the value chains and pressures related to fisheries, recreation and tourism, or extractive industries. It could be used to evaluate a sector, such as Dive Tourism on the Great Sea Reef or the North Atlantic Lobster Fishery, or to evaluate all sectors in a specific geographical region. The TEEB for Coasts Framework could also be used to guide inclusive wealth accounting or other monitoring and evaluation efforts.

Failure to account for intergenerational equity, acknowledge planetary limits, and balance tradeoffs between multiple objectives has constrained progress toward the SDGs (Lim, Søgaard Jørgensen, & Wyborn, 2018). Taking a capitals approach gives an inclusive intergenerational perspective because capital stocks need to be increasing, per capita, for increases in well-being to be sustained in the long term. Sustainability is best achieved through an integrated balance of human, natural, and produced capital[30]. Rather than taking decisions to maximize income or short-term impacts, the TEEB FOR COASTS framework will help public and private decision makers maximize intergenerational 'inclusive wealth' within planetary boundaries.

It is not enough to undertake cost-benefit analysis alone to ensure sustainability is included within the decisions[31]. There is very little substitutability between natural capital and other forms of capital, which suggests that there is no way to ensure sustainability by allowing for substitutability. While technological changes could increase this relationship over time, understating and modelling the natural-human systems is important to ensure sustainability can be achieved, and build on the substitutability between capitals. However, given the reliance of human life on natural systems, providing 'life support systems' which suggests that there is a limited to substitutability, and ultimately sustainability requires management of the resource that does not exceed the rate of self-replenishment. Amongst other this is a very strong message which comes through from the recent Dasgupta Review of the Economics of Biodiversity.

3.1 Comparing Scenarios

Every decision or choice has the potential to leads to a scenario that will result in different a set of outcomes. Tradeoffs are the comparative impacts, the benefits and costs, of two or more scenarios. Measuring the often invisible tradeoffs between scenarios that arise in coastal areas is key step towards achieving sustainable, equitable outcomes. In order to measure tradeoffs, we must first identify the scenarios that would occur as a result of decisions that could be taken.

The TEEB for Coasts framework can be applied to different type of problem, the kind of scenarios which may be of interest in a coastal context include:

[30] Reference - Inclusive Wealth 2018

[31] Bateman, I.J. and Mace, G.M., 2020. The natural capital framework for sustainably efficient and equitable decision making. *Nature Sustainability*, *3*(10), pp.776-783.

- **Policy scenarios** – these might include looking at regulations or incentive programs. The needs and focus will vary depending on the policy question. For example, policy to improve appraisal of infrastructure projects might ensure that the values of coastal wetlands are better recognized and need to estimate the impact this will have on reducing habitat losses, where as a spending programme to restore coastal wetlands might need to examine which wetlands and for what benefits the programme wishes to protect. Policy scenarios might be built to examine how the costs and benefits to society change with different priorities, for example:
    - Scenario 1 – focusing on protecting nature
    - Scenario 2 – focusing on extractive uses
    - Scenario 3 – Tourism development vs. conservation
    - Scenario 4 – Business as usual vs. integrated management of tourism, fisheries and conservation

- **Economic development scenarios** – these would focus on comparing business models or options within a sector to capture economic benefits in the coastal zone, as such scenarios could considering the impacts of different private sector investments or infrastructure projects, for example looking at:
    - Fish farming vs wild capture fisheries, or
    - Tourism balance – cruise ships vs eco-tourism

- **Typology scenarios** – these focus on comparing specific ways of carrying out activities or technology choices, for example:
    - Trawling vs. Long-line fishing

- **Exogenous demand shifts** – this type of scenario looks at the impact of changes in external drivers and the potential responses to these, for example, how to respond to:
        - Demand for marine minerals for technological innovation
        - Shift in preference from white fish to shellfish

Whilst the types of scenario differ, the evaluation framework remains constant as highlighted in the summary graphic below. This means that the framework can provide consistency in how impacts are understood, trade-offs recognized and choices are made.

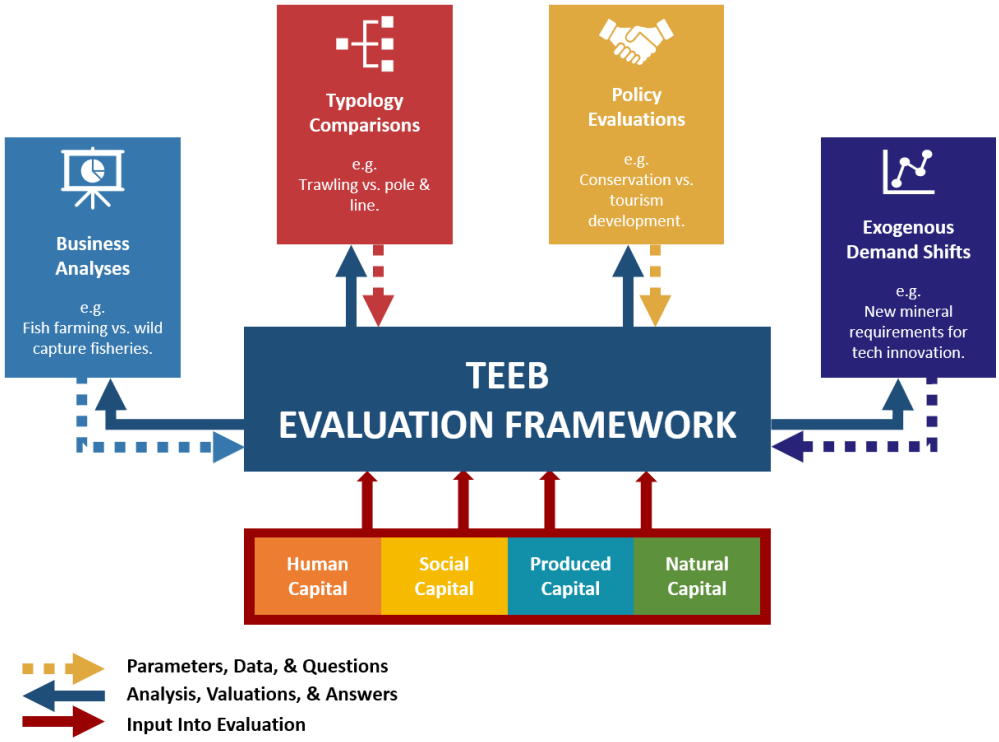


Figure 3 Potential options which can be examined by applying the TEEB for Coast Framework

3.2 Recognizing tradeoffs

Tradeoffs in scenarios may arise in various ways. Simple tradeoffs which arise between visible flows faced by the same economic actor are likely to be internal to the choice they make. In reality, however many tradeoffs are hidden. They arise because complex, interlinked systems can result the failure to identify and capture important outcomes and impacts that arise as a direct result of original decision. Decision makers can fail to account for tradeoffs if they fail to identify all the linkages, fail to recognize economically invisible flows, or fail to reflect the voices of those who are impacted by a decision but do not have a voice in making it. Analysists must find way to assess the complete, dynamic system to understand the magnitude of hidden tradeoffs. Taking this kind of approach means recognizing how changes have ramifications through biophysical, and socio-economic connections.

Describing the complete, dynamic system reveals the variety of tradeoffs we face. There are likely to be a wide range of trade offs including but not limited to:

- sectoral tradeoffs (e.g. shipping vs. tourism);
- stakeholder tradeoffs (e.g. subsistence fishermen vs. commercial)
- tradeoffs between capitals (e.g. where natural capital assets are lost as a result of the creation of new produced capital such as grey infrastructure);
- temporal tradeoffs (e.g. where the decisions of today's generation impact the opportunities the will be available for future generations);
- geographical tradeoffs (impacts in one place that arise as a result of decisions in another)

Identifying hidden tradeoffs will also identify important stakeholders whose views and preferences may not be reflected in the way choices are currently made. Making tradeoffs more explicitly, and recognizing both the winners and losers from choices that are made, can help to identify both better choices and better ways to implement decisions, especially through supporting those who lose out.

3.3 Decision making for sustainability and achieving the SDGs

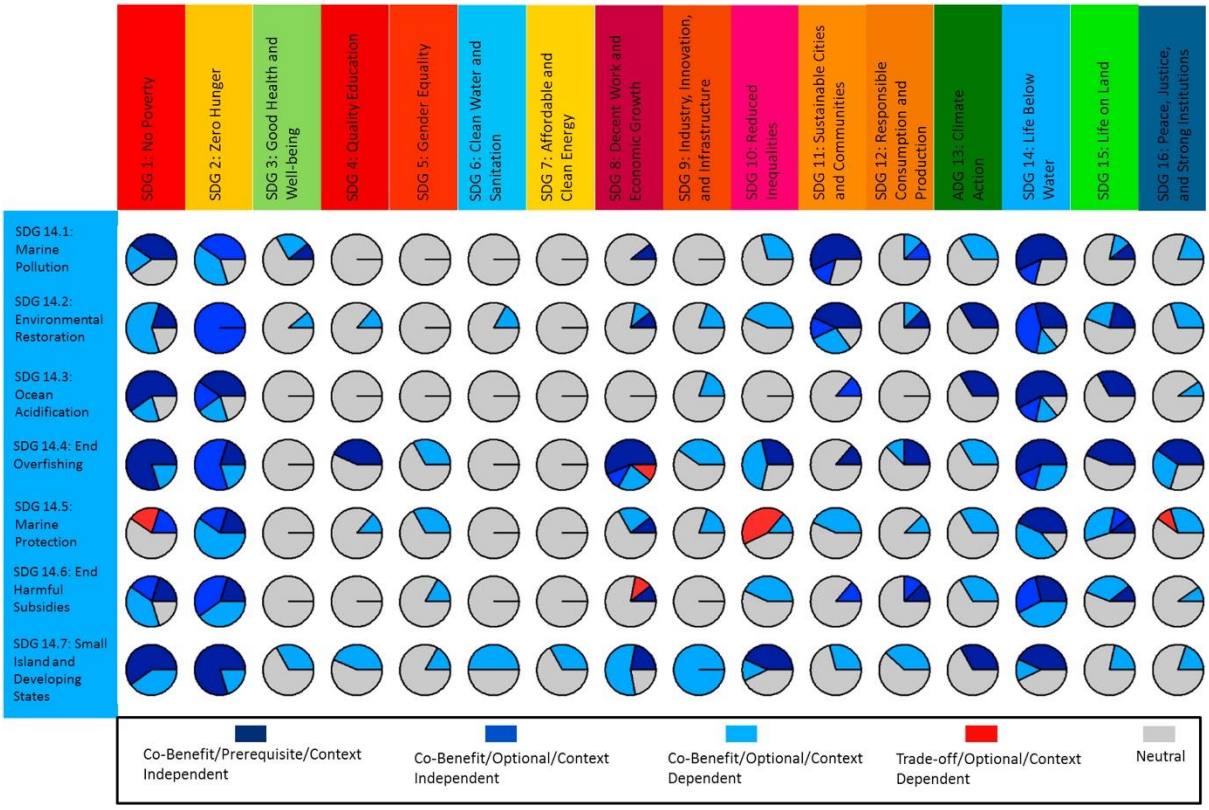
The capitals approach, by identifying the potential to increase wealth and understanding how the benefits of that wealth are distributed, is designed to help to manage and balance tradeoffs, especially by ensuring that visible and invisible flows, and connections between capitals and their beneficiaries are taken into account.

Recognizing and managing potential tradeoffs is also integral to the delivery of the sustainable development goals, as revealed in a rapid assessment of the co-benefits and tradeoffs amongst sustainable development goals which focused the delivery of SDG 14, Life Below Water[32]. The targets which make up goal 14, specifically 14.1 to 14.6 shown in the figure below target progression towards a health ocean, and are therefore focused on protecting the state of marine natural capital assets. Features of marine natural capital include for example, the quality of the water, the level of fish stocks or the condition of coastal habitats. The table highlights the connections between meeting the targets under goal 14 and achieving the targets under other goals, showing the link between maintaining natural capital in the ocean and delivering outcomes in terms of, for example, human health, food security and adaptation to climate change. Importantly it shows where there may be tradeoffs between the protection of natural assets and access to food and employment – with ramifications for the human and social capital stock. Understanding how to avoid and manage these tradeoffs is critical to sustainable development.

Synergies are also important to capture, where one capital is complementary to another, i.e. it reinforces its value e.g. fishing boats will be more valuable where a fish stock is sustainably managed.

[32] Singh GG, Cisneros-Montemayor AM, Swartz W, Cheung W, Guy JA, Kenny T-A, McOwen CJ, Asch R, Geffert JL, Wabnitz CCC, Sumaila R, Hanich Q, Ota Y (2017) A rapid assessment of co-benefits and trade-offs among sustainable development goals. Marine Policy.

Figure 5: Connections between meeting targets under goal 14 and meeting other SDGs



Blue in the pie charts represents benefits of meeting targets under goal 14 for other goals. Dark blue show where meeting targets under goal 14 are a pre-requisite for achieving other objectives. Red areas show where there may be trade-offs (most of these relate to the potential impacts on people's livelihoods if access to particular resources – usually fisheries – are reduced).

What matters for decision makers on Andros Island (Natural Capital Project, 2017)

The drafting of a Sustainable Development Master Plan for Andros Island, conducted with the help of the Natural Capital Project, demonstrates the first two steps of the TEEB 6-step process - identifying the potential policy questions and scenarios. Most of the key pillars for Andros are synonymous with the Sustainable Development Goals. The TEEB for Coasts Framework supports implementation of the 2030 agenda by measuring indicators across all four capitals

"The goal of the Sustainable Development Master Plan for Andros Island is to provide a comprehensive framework and actionable plan for guiding decision making and investment over the next 25 years by addressing eight key pillars identified by the Androsians:

1) ***Food and water security*** *are important regarding food and freshwater supply throughout the island. They can be sustained by better infrastructure to transport goods (roads, water mains, harbors), sustainable fishing practices and stock monitoring, development and best management practices in agriculture and forestry reducing risk to land crab habitat and freshwater,*
2) ***Connectivity and accessibility*** *are important regarding the possibility for Androsians to access opportunities and services. They can be sustained by better transport infrastructure (roads, bridges, airports), secured nautical access to main harbors and new ferry services linking each district and Nassau, improving access to the island for tourists as well as facilitating movement for locals,*
3) ***Education and capacity building*** *are important regarding Androsians' knowledge and possibility to access job opportunities. They can be sustained by the improvement of school infrastructure and the implementation of different types of training regarding fishing, agriculture, forestry and naturebased tourism activities, fostering the ability of the Androsians to make the best of their wealth of natural resources,*
4) ***Livelihoods and income equality*** *are important regarding the development of social and economic capital. They can be sustained by better infrastructure and the economic development of fishing, agricultural, forestry and naturedbased activities, increasing visitation and total expenditure,*
5) ***Land use planning*** *is important* ***for sustainable development and the exploitation of land and marine natural resources****. It can be enforced by defining development and no-development areas,*
6) ***Health and wellbeing*** *are vital, they can be sustained by better social infrastructure (clinics, schools, sport centers), better connectivity with Nassau (airports, harbors), development and best management practices in agriculture and fishing,*
7) *The development of activities in Andros, governed by enforced or new policies can* ***strengthen local government****, through more responsibilities,*
8) ***Coastal resilience*** *is crucial considering the high vulnerability of Andros to climate change effects (sea level rise, flooding, erosion). It can be sustained by the conservation of key natural habitats (mangroves, coral reefs and seagrass), enhanced by sustainable fishing, agricultural and forestry practices, the enforcement of policies and protected areas. On the other hand, infrastructure development near the shoreline can amplify coastal risks linked with climate change and sea*

What is the TEEB for Coasts Evaluation Framework?

4 A TEEB for Coasts Evaluation Framework

4.1 Putting it together: A universal 'capitals-based' framework for evaluation

Chapter 1 explained how humans are making decisions that jeopardize the future of marine & coastal ecosystems and therefore the sustainability of economic activities and livelihoods in these regions. Poor choices are occurring because decisions are being made based on partial, incomplete, piecemeal assessments of the impacts and outcomes of these decisions. Decision makers need guidance to understand the implications of choosing options and support to navigate the complex trade-offs that choices involve in coastal areas. We propose that a TEEB for Coasts measurement and evaluation framework be used to guide comparison of the status quo to hypothetical scenarios or to guide assessment and monitoring of the status quo.

The Framework will guide:

- scoping and conducting a comprehensive cost/benefit analysis;
- quantifying the true costs and benefits of inaction; and
- the tradeoffs of alternative actions in complex, multi-sector coastal areas.

TEEB typically works with stakeholders across national government ministries to compare alternative policy scenarios. However, the TEEB for Coasts framework could also be used to compare alternative initiatives and investments, including private business investments. For any assessment, the framework answers the question "What should be measured?"

The basic premise is that the framework is broadening the lens through which we evaluate things. By modeling and demonstrating the complete set of public and private social and environmental impacts of scenarios, it allows policy makers, planners, and business leaders to understand the long-term effects of a particular decision. By combining existing methods and models from the social and physical sciences, a TEEB for Coasts assessment evaluates dynamic multi-sectoral *human-nature relationships,* accounts for economically invisible *non-market impacts*, and estimates changes wealth over time to help understand impacts with regard to *intergenerational equity*. The ultimate result is analysis of human welfare under a given scenario or a comparison of expected changes to human wellbeing under alternative scenarios.

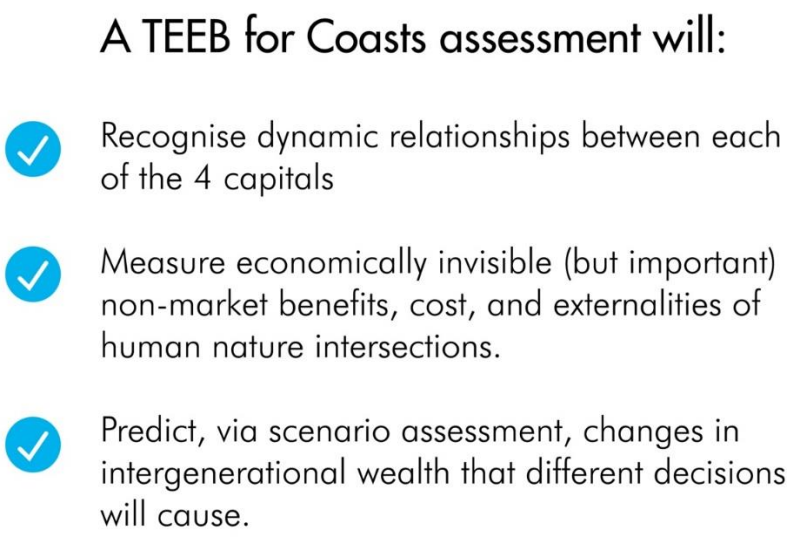


Figure 6 A TEEB for Coasts assessment in a nutshell

We know that coasts are made of many complex and dynamic interactions, not just between the economy and nature, but also between people and governance systems. The foundation of the TEEB for Coasts evaluation framework is identifying all those relationships. Using the four capitals approach, the human welfare implications of existing systems and potential alternative scenarios can be compared. This comparison is achieved by assessing all four capitals (human, natural, produced, and social), and then mapping and measuring the connection between the condition of those capital stocks and the associated flow of outputs and outcomes, accounting for limitations of substitutability of capitals. The TEEB approach is comprehensive in the way that it guides analysis of all four capitals and inclusive in the way that it supports analysis of all components and stakeholders of the dynamic system, across sectors up and down the value chain through the full life-cycle.

To facilitate assessments the Framework will act like a checklist of important indicators for stakeholders to consider and for researchers to measure and model. Although it will not prescribe specific modelling techniques, it maps the flow of outcomes, externalities, impacts, and residuals to and from the four capitals and identifies connections and feedbacks between the flows. The Framework provides parameters or metrics to evaluate, in the form of four capitals and associated flows, breaking them into individual indicators by exploring real-world examples. It then explains how to approach the evaluation through comparing stakeholder-generated scenarios to a Business-as-Usual (BAU) counterfactual over a long-term (e.g. 20+ year) planning horizon.

The comparison of all stocks, flows, and impacts can be qualitative or quantitative, and in biophysical terms or monetary value. Although TEEB encourages and supports countries to use economic valuation, the Framework recommends monetary valuation only if desired by stakeholders and when it is methodologically appropriate to answer the given policy question.

The table below provides an example of the capital stocks and flows that may be impacted in a hypothetical scenario whereby investments are channeled into mangroves as a natural based solution to improve climate resilience. The flows to and from two specific sectors are examined with significant flows outside these sectors also recorded.

Table 3 Draft Visualization of TEEB for Coast Evaluation Framework Application

Capital Asset	Associated flows - Sector / Supply Chain A (**coastal communities**)		Associated flows - Sector / Supply Chain B (**fishing**)		Wider flows of societal significance beyond A & B	
	Input to human well-being / economic activity provided by capital stock	Impact on capital stock arising from change in human activities stimulated	Input to human well-being / economic activity provided by capital stock	Impact on capital stock arising from change in human activities stimulated	Input to human well-being / economic activity provided by capital stock	Impact on capital stock arising from change in human activities stimulated
Restored Mangrove (Natural Capital)	Reduced exposure to damage from tropical storms		Increase in habitat for lobsters, crabs and juvenile fish			Increase in biodiversity Increase in carbon stock
Coral Reefs (Natural Capital)				Potential pollution / damage from increased recreational fishing tourism		
Coastal Community (Social Capital)	Local knowledge on restoration and sustainable use of mangroves	Increased food security	Plan for ensuring sustainable harvesting of valuable species	Increased commitment to cooperative management of public goods		
Coastal Homes and Business Premises (Produced Capital)		Reductions in storm damage Increased opportunity to develop ecotourism		Increased income and profit at local hotels / businesses associated with recreational fishing tourism		Potential increases in tax revenues, and decreases in spend on seawall maintenance / disaster recovery
Local workforce (Human Capital)	Labour required to carry out restoration	Improved health status from increase in protein available		Increased income from additional catch of crab and lobster		

4.1.1 Learning from the TEEBAgriFood Evaluation Framework

Since 2010, TEEB has strived to develop, test, and improve guidance for evaluation of anthropogenic activities that identifies and measures the value of nature and captures it in decision making. In doing so TEEB gives nature a seat at the decision making table. With the creation of the TEEBAgriFood Evaluation Framework[33], TEEB pioneered a guide to evaluate all capital stocks and associated flows of benefits and pressures within agri-food systems. The guide is universal, inclusive, and comprehensive in that it can evaluate any set of questions about agriculture and food systems. TEEBAgriFood showed that any issue can be evaluated and any scenarios can be compared using a capitals approach. We propose the TEEB for Coasts Evaluation Framework build upon the TEEBAgriFood Framework for assessing anthropogenic activities in coastal areas. By building upon an existing framework to help guide sustainable blue economies we leverage the thousands of hours and millions of dollars spent on TEEBAgriFood, creating a large opportunity for impact. TEEB for Coasts is not reinventing the wheel, but rather using the wheel to invent the cart

4.2 Applying a TEEB for Coasts Framework

A measurement and evaluation framework to quantify impacts, compare trade-offs and identify synergies is just one step in the process toward better decision making. It will only be helpful in generating transformative change if it can be put to purpose, and that purpose is providing information to facilitate and support decision making. The types of decisions that could benefit from this type of support range from local development decisions made by a city council to national policies debated and enacted by parliament. The TEEB for Coasts framework could be applied to a range of private decisions as well, for example to help a local business choose between waste management options or to help a multinational company plan their global multi-modal transportation strategy. In order to implement the proposed framework for measuring stocks, flows, outcomes, and impacts we must first identify relevant decision options and scenarios that those decisions would create. This analytical framework for

[33] http://teebweb.org/our-work/agrifood/understanding-teebagrifood/evaluation-framework/

comparing scenarios and assessing tradeoffs of decisions is just one building block to a sustainable blue economy. And valuing the invisible is just one step in the process towards change. All TEEB assessments follow a six step approach that assures the assessment contributes to positive change.

Figure 7: Six steps *of a TEEB for Coasts assessment*

Steps	STEP 1. Refine the objectives of the TCS by consultations on the key policy issues with stakeholders	STEP 2. Identify the most relevant ecosystems and ecosystem services	Step 3. Define information needs and select appropriate methods	STEP 4. Assess and value ecosystem services	STEP 5. Identify and outline pros and cons of policy options, including distributional impacts	STEP 6: Review, revise, and report study results
Key outputs	• Clearly defined objectives and scope for the study, with the appropriate level of stakeholder involvement, especially from national and local policy-makers • Basic grasp of the differences in perspectives and potentially conflicting interests across different policy dependencies as well as impacts. • Understanding of which institutions currently govern ecosystems and biodiversity and how decisions are made. • Brief problem statement that can be referred to in order to guide the study.	• Basic understanding that can guide assessment of how different stakeholders value and prioritize ecosystem services. • Key concerns identified with regard to ecosystem degradation or loss, the main drivers and trends, and related stakeholder groups. • List of prioritized ecosystem services which are linked to the objectives of the study.	• Clarity on what information needs to be generated and how this information will be used to further the overall objectives of the study. • Decision made regarding methods to be used, with justifications for the choice provided. • Clarity on key data sources and matching of intended methods with data, time, capacity and resources available for conducting the analyses.	• Assessment and valuation of relevant ecosystem services, including the trends in usage, degradation, ecosystem health, and resilience. • Detailed understanding and assessment of the key drivers of changes (what and by whom) in ecosystem service provision, and how stakeholders are affected by the changes. • Understanding of how the benefits associated with ecosystem services and the costs associated with their degradation are distributed.	• Broad outline of currently existing policies and alternative policy options or measures, tested against consistent criteria including distributional implications. • List and brief description of policy options or measures which show promise, giving a broad rationale. • If relevant, assessment of ecosystem service provision under different policy scenarios or use options, including the trade-offs involved. • Recommendations on how to best deal with un-avoidable negative distributional impacts that may arise.	• Review of study with recommendations either integrated into the study or clear reasons given for non-integration. • Final reporting appropriate to the needs of targeted decision-makers and other audiences. • Statement of recommended criteria and indicators to be considered for impact analysis and regular reporting of outcomes, after recommended policy changes are implemented

The key first step to making an impact is designing the assessment to answer decisions makers' questions. The results of the assessment should enable decision makers to understand the implications of their options and point to decisions that will lead to best outcomes. Decision makers and stakeholders need to define the research questions based on realistic descriptions of the status quo and alternative options, options which decision makers have agency to influence. Researchers need to translate these descriptions into scenarios that can be modeled and compared, and validate these options with the stakeholders they will impact.

Secondly, researchers need to determine what key metrics or indicators decision makers care about. These measures are key to capturing the attention of the decision maker and making the assessment relevant. But it is unlikely that decision makers are prepared to articulate measurement of all four capitals and list indicators to quantify all potential impacts of a scenario. This is where the TEEB for Coasts framework adds value. Explaining the capitals approach demonstrates the breadths of impacts related to any scenario and the importance of taking decisions that maximize intergenerational wealth.

Steps 3 and 4, assessing information requirements and building empirical models, requires interdisciplinary technical expertise. Step 5 is the development of a theory of change, a roadmap to get

from scenario A to scenario B. And step 6 is an approach for assessment of how well the evaluation has been able to answer the decision makers' questions, allowing for adaptation where the assessment has failed.

The Sustainable Blue Economy Decision Support Framework, by helping countries articulate a vision and pathways to achieve that vision, can uncover questions from decision makers and issues that would benefit from this more holistic type of assessment. The Decision Support Framework could determine the issue and clarify the purpose of an assessment, it could also identify stakeholders and frame the assessment within a broader theory of change.

A potential application of the proposed TEEB for Coasts Framework

Suppose a coastal city is drafting an implementation strategy for their five year development plan. They want to know what actions need included in the strategy to achieve the targets set in their development plan for generating just employment, protecting vulnerable populations, and generally building a more sustainable, resilient community. As the city council discusses what should be included in the implementation strategy, a thousand options emerge. The implementation strategy could target job creation with business development incentives, expanding rights to access non-renewable resources, or by restoring and protecting depleted renewable resources. It could target housing equity with changes to zoning rules or rental regulations. It could support public health with infrastructure investments to update coastal wastewater disposal systems or draft pollution laws and mechanisms to force industries to comply. Any of these individual decisions will have far reaching implications which the TEEB for Coasts framework could help explain and quantify. The framework helps the decision makers paint a picture of their future community, it's wealth and wellbeing, by making the links between seemingly disparate parts and actions. In this way TEEB for Coasts brings to the table a compelling instrument – a crystal ball.

4.2.1 Scoping an assessment to use the TEEB for Coasts Evaluation Framework: by geography, sector, governance/jurisdiction, ecosystem, or stakeholder

We have suggested that a capitals-based evaluation framework can guide assessment of multi-sector, multi-stakeholder scenarios in coastal areas. Because of the numerous interlinked jurisdictions, sectors, value chains, and ecosystems in coastal 'ridge-to-reef' areas, it can be challenging to decide where a TEEB for Coasts assessment begins and ends. This framework is being developed to aid decision making, therefore the starting point should always be a question. It could be a policy question or a question about a business decision. But where does the assessment end? What defines the scope of the analysis?

We propose the TEEB for Coasts Evaluation Framework could be applied to assess any issue on land that has impacts upon the sea, and any coastal issue within national jurisdictions (Exclusive Economic Zones). An assessment may focus on a specific product, practice, policy, or even an entire system or value chain. It may be looking forward or backward or at changes over time, or comparing the forecast impact of different choices. It may focus on a business, a region, or even a country. It may be concerned with specific impacts like changes to fisher incomes or broad impacts like regional biodiversity.

To ensure that the application of the TEEB for Coasts Evaluation Framework is effective, we suggest four criteria which would ideally be met when scoping an assessment:

i) It should focus on issues that can be influenced by decision makers who are or are willing to be engaged in the assessment and, for example, the policy developments that will be needed to implement change.
ii) It must recognize diverse, interconnected systems from ridge-to-reef, acknowledging that this may extend the assessment beyond the impacts of usually of primary concern to decision makers and extend the cohort of decision makers that need to be engaged.
iii) Scenarios to compare options, should be defined with decision makers, and provide feedback in issue that they are interested in.
iv) Build from pre-defined regional planning boundaries, encouraging joint working across administrative boundaries.

4.3 The Niche of TEEB for Coasts in the assessment landscape

The TEEB for Coasts evaluation framework joins a landscape of existing assessment tools and frameworks. TEEB for Coasts draws on some of these existing approaches and adds important new perspectives. Specifically, TEEB for Coasts aims to fill two important gaps in the existing landscape of assessment frameworks by integrating the four capitals and focusing on the coastal area. This short section highlights the niche of TEEB for Coasts among existing assessment approaches.

The capitals approach that TEEB for Coasts is based on aims to break down the silos between natural, human, social and produced capital. This requires bringing together a variety of disciplines. Existing approaches, such as natural capital assessments or accounting, also seek to integrate environmental, economic and social considerations and inform trade-off decisions. However, these approaches tend to focus on only one capital. Whereas TEEB for Coasts includes all four capitals into one integrated assessment that can be applied to the comparison of scenarios for different types of decision-making contexts.

Bridging the land-sea divide in governance assessments and applying assessment and accounting approaches to marine and coastal ecosystems, present particular challenges. These challenges have to do, among other factors, with a) the remoteness of and difficult access to marine ecosystems, b) lack of geographical boundaries, c) unclear or overlapping jurisdictional boundaries, and d) a vast number of stakeholders with different needs and interests. Applying generic assessment approaches or methodologies from other areas to this particular marine and coastal context without specific guidance is challenging. While assessments are already being undertaken in coastal areas, to the best of our knowledge, currently no globally applicable framework exists to provide this guidance. TEEB for Coasts aims to provide this guidance.

The proposed TEEB for Coasts is a methodological framework that guides the user through the evaluation of different scenarios compared to the business-as-usual situation. This comparison of options is based on an assessment of different capitals, flows and values of ecosystem services. To implement this, TEEB for Coasts draws on existing tools and approaches, including spatial mapping using geographic information systems (GIS), ecosystem service valuation, policy analysis and others.

The following two subsections take a closer look at the links and differences between TEEB for Coasts, existing natural capital frameworks and the driver-pressure-state-impact-response framework (DPSIR), and what TEEB for Coasts adds to these approaches.

4.3.1 Links between TEEB for Coasts and natural capital frameworks

A range of approaches already exist that focus on natural capital and aim to integrate the value of nature into economic and development planning, policy and management decisions. These approaches include natural capital or ecosystem assessments, natural capital or ecosystem accounting, environmental impact assessments and ecosystem service valuation. The different natural capital evaluation approaches connect people and the economy with the natural environment, identifying and describing important relationships. These relationships include the benefits and values that nature delivers to people, and the impacts and dependencies that people have on nature. Understanding these relationships is essential for achieving the integrated approach to environmental management and economic and social welfare planning essential to sustainable development.

Natural capital assessments and integrated ecosystem assessments provide decision makers with information about the state of natural assets and resources and the benefits and values that nature delivers to people, making these benefits and values explicit. These assessments are spatially explicit and involve a) mapping of ecosystems and ecosystem services, a) appraisal of biophysical information on the natural capital (physical measures of ecosystem extent and condition and of expected service flows), c) qualitative assessment of sector dependencies and impacts on the natural capital and the beneficiaries of service flows, d) temporal modelling of service provision, and e) valuation of the ecosystem service flows in monetary or non-monetary terms. The evidence base that these assessments provide demonstrates the impact of the economy on the natural environment, and the contributions of the natural environment to the economy. The information that these assessments produce can help understand trade-offs and synergies between different policy options and support the comparison of different future scenarios.

As such, existing natural capital evaluation approaches provide a similar function to TEEB for Coasts. The main difference is that these approaches focus on only one capital. While considering the flows of services and benefits from the natural capital to people in terms of social and economic wellbeing, they do not consider interactions with human, social and produced capital. Moreover, there currently is no specific guidance on natural capital evaluations for marine and coastal ecosystems. Thus, TEEB for Coasts compliments the existing approaches by adding consideration of the other three capitals and providing a specific marine and coastal focus. Further, TEEB for Coasts may draw on existing natural capital or ecosystem assessments or make use of methodologies for these assessments.

Natural capital assessments are closely related to the process of **natural capital accounting or ecosystem accounting**. Both assessment and accounting follow the approach set out in the United Nations System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) framework. Natural capital or ecosystem accounting is a systematic and standardized way of organizing and integrating ecological, economic and social data related to natural capital assets and the services and benefits they provide to people. By using the same concepts and classifications as the System of National Accounts (SNA), a coherence between data can be achieved that can support integrated environmental-economic analysis and planning. Ecosystem accounts include ecosystem extent, condition, ecosystem service supply and use, and ecosystem service values. The proposed SEEA Ocean Accounts Framework combines these ecosystem accounts with wider environmental accounts on physical inputs and emissions from the SEEA Central Framework (SEEA CF), economic data from the System of National Accounts and governance accounts for the ocean. Ecosystem accounts help track change in ecosystem assets and the services, benefits and values they provide.

The information collated in accounts provides statistics and indicators that can be used to reveal trade-offs, dependencies and risks, inform and justify policy and development decisions, and track progress against environmental commitments. Thus, SEEA also facilitates the integration of data across natural, economic and social capitals to inform decisions. Moreover, with the Ocean Accounts Framework, it provides a focus on marine and coastal ecosystems. However, accounts only help track change over time looking backwards. Whereas TEEB for Coasts includes all four capitals into one integrated, forward looking assessment.

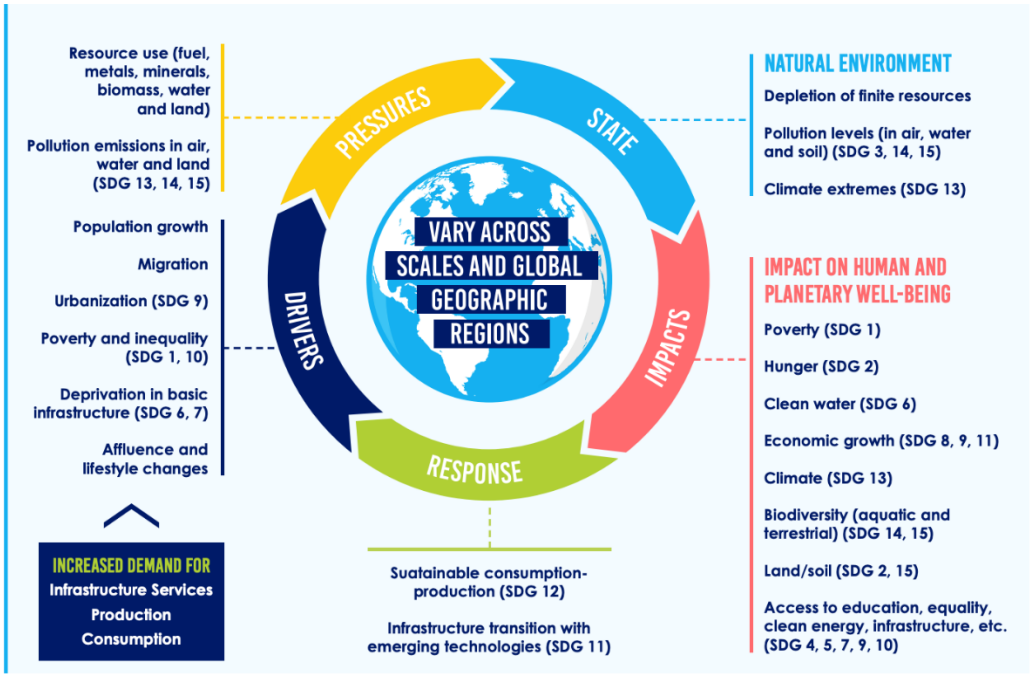
4.3.2 Complementing the driver-pressure-state-impact-response framework through TEEB for Coasts

The driver-pressure-state-impact-response framework (DPSIR) is a causal framework developed by the European Environment Agency to describe human impacts on the environment. The capitals approach pioneered by TEEB transforms DPSIR into an analytical framework that can measure and compare scenarios to aid decision making. TEEB adds detail to each step and the processes between the steps in the DPSIR loop so that the state and impacts can be modeled, measured, and compared.

Figure I.2

DPSIR FRAMEWORK AND THE SDGS

Socioeconomic **drivers** from human activities are the first factors in the chain of causal links. These drivers cause **pressures** on the environment, which in turn affect the **state** of the environment. The changing state of the environment can be seen through environmental and human **impacts**. A **response** is needed that can influence the key drivers and enable positive changes throughout the entire system through a continuous process.



Source: International Resource Panel (2019), *Global Resources Outlook*[18]

Drivers may arise from external factors such as market demands or climate change, or they may be within the decision makers control, such as polices or initiatives. Drivers may motivate a real or hypothetical decision or series of decisions that result in a scenario, a set of human activities or enabling environment for activities, such as rules or regulations. A scenario is a comprehensive picture that helps explain how a driver causes a pressure.

Pressures could be both positive or negative. TEEB suggests that pressures can be measured as changes to the four capital stocks. The result of these changes is the state, the extent and/or condition of the capital stock. Over time, the state of our capital stocks lead to outcomes. Outcomes may have direct or indirect impacts on human wellbeing. TEEB refers to the relationships between pressures, capitals, and impacts 'flows'.

The capitals approach focuses attention on the relationships between scenarios, the outcomes of drivers, and pressures. It also focuses on the relationships between pressures and the extent and condition of each capital (state) and between the capitals and human impacts. Determining how to measure and model these relationships, these flows, is what distinguishes the TEEB for Coasts framework from DPSIR.

4.4 The role of TEEB FOR COASTS in supporting decisions for a sustainable blue economy

The Sustainable Blue Economy is an opportunity to reframe our interaction with the marine and coastal environment, to consider a more wholistic integrated approach. However, embracing this opportunity may need changes in the way that policy, sectors and stakeholders interact with the marine environment. In order to enable a new, wholistic, integrated perspective on the blue economy, the Sustainable Blue Economy Transition Framework defines the Sustainable Blue Economy through five guiding principles; healthy ecosystems, equity and inclusivity, climate stability, sustainable consumption and production, and circular processes. The Transition Framework supports countries in understanding their starting point, developing a shared national vision for their Sustainable Blue Economy and delivering this vision through integrated policy, adaptive planning and management.

TEEB for Coasts is embedded in the Transition Framework as an integrated assessment approach that measures the stocks and flows of the four capitals, revealing trade-offs and interactions between them. As a result, it is particularly well placed to compare policy options and to support scenario analysis when considering the different pathways towards a Sustainable Blue Economy. The Transition Framework takes a systems wide view of the issues that countries face, thus allowing identification of key questions that need answering. TEEB for Coasts is able to provide the systems thinking and scenario comparison across the four capitals to help answer those questions.

5 Conclusions

5.1 Next Steps

This document has explored the foundations and utility of a TEEB for Coasts Evaluation Framework, and highlighted its potential value. The next steps build on recommendations from a series of expert workshops which supported the development of the report.

For the TEEB for Coasts evaluation framework to be widely adopted and applied, the most critical need is for the development of guidance on how to complete the framework alongside pilot testing of the

approach to develop case studies and proof of concept in the field. Particular attention should be paid to defining the boundaries and scope of the assessment, it is envisaged at this stage this will be driven the question that is being tackled, the feasibility of this should also be tested. The importance of incorporating guidance on how to apply and use the framework and the way of thinking it encourages in the context of data deficiencies was also flagged.

The process of testing of the framework could also be used to refine and improve the draft diagrams and tables within this report to ensure that they are able convey the TEEB for Coasts approach quickly and accurately, as these were also viewed as important to the successful use and uptake of the approach.

The formation of a steering committee or advisory board was proposed as an option to help move forward the TEEB for Coasts initiative and ensure that it is able to add value in rapidly developing field.

5.2 Research Gaps

Although it was highlighted that these should not delay the next steps above, some research gaps were identified in the expert workshops which supported the development of this report. In particular; how to build relationships between earth system boundaries and jurisdictional boundaries; how to recognize and capture thresholds and tipping points; and how to reflect these in applications of the TEEB for Coasts evaluation framework. Further research was also advised on methods to evaluate social and human capital in the coastal space, and around understanding of the different value chains operating in coastal systems and their boundaries.