United Nations | Department of Economic and Social Affairs

Natural Capital Accounting For Sustainable Macroeconomic Strategies

System of Environmental Economic Accounting

United Nations | Department of Economic and Social Affairs
Statistics

Natural Capital Accounting For Sustainable Macroeconomic Strategies

United Nations publication issued by Department of Economic and Social Affairs.

With funding from the Federal Ministry for Economic Cooperation and Development of Germany, www.bmz.de, implemented by Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH, www.giz.de.

With funding from the

Federal Ministry
for Economic Cooperation
and Development

Supported by

giz
Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

ISBN: 978-92-1-259155-1
eISBN: 978-92-1-005251-1
Sales No: E.20.XVII.15

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The Statistics Division of the Department of Economic and Social Affairs is a global centre for data on all subject matters, bringing to the world statistical information compiled by the entire UN system. It is committed to the advancement of the global statistical system, by compiling and disseminating global statistical information, developing standards and norms for statistical activities, and supporting countries' efforts to strengthen their national statistical systems. It also facilitates the coordination of international statistical activities and supports the functioning of the United Nations Statistical Commission.

The System of Environmental-Economic Accounting (SEEA) is the first international statistical standard for environmental-economic accounting, which was adopted by the United Nations Statistical Commission at its 43rd Session in 2012. The SEEA brings together economic and environmental information into a common framework to measure the contribution of the environment to the economy, the impact of the economy on the environment, and the condition of the ecosystems and the services they provide.

For further information on the SEEA, please visit seea.un.org or contact seea@un.org.

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EXECUTIVE SUMMARY

Human activity (e.g. agricultural expansion and intensification, the burning of fossil fuels, increased urbanization etc.) is directly undermining both climate and ecological systems upon which human well-being and economies depend.

Whilst key financial players, such as treasury departments, central banks and financial institutions, are increasingly concerned by the social, economic and political risks and consequences that can be brought about by poor natural resource management, they are, at the same time, interested in the myriad of opportunities that comes with the transitioning towards a sustainable, low-carbon economy.

Taking advantage of the opportunities to deliver long-term sustainable growth and prosperity for people and the planet requires decision-makers to move "beyond GDP", placing greater emphasis on assets and wealth – stocks of natural, social, human and physical capital – rather than just income flows. These stocks are the drivers of future growth in productivity and well-being.

Climate change and environmental degradation are the result of poor capital management, particularly the management of natural capital. Natural capital refers to the stocks of environmental assets (including natural resources[1], ecosystems and a stable climate) that generate flows of goods and services into the economy. Greenhouse gases (GHGs), pollution, deforestation, overfishing and biodiversity loss are all examples of natural capital depletion.

Natural capital is fundamental to every economy but, in practice, is poorly reflected in official statistics. The benefits that it provides, such as air and water purification, crop pollination, nutrient cycling etc., are largely excluded from national accounts, meaning that a value of US$0 is implicitly placed on such crucial ecosystem services. Indeed, among all the key asset stocks, natural capital is perhaps the only one that is in decline worldwide, which thereby threatens to undermine the returns to all complementary assets, including physical, social and human capital.

The System of Environmental Economic Accounting (SEEA) is the international statistical standard for natural capital accounting (NCA) (see Hoekstra, 2020, for an overview). It can be applied across countries and is consistent with the System of National Accounts (SNA) which is the foundation of official economic statistics (see Annex). Crucially, it organizes

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[1] These resources include raw materials such as fuels, minerals and metals, but also soil, water, timber, water and aquatic resources (United Nations et al., 2014a).

environmental-economic data in a way that is fit for inclusion in mainstream macroeconomic analyses. Implementing the SEEA ensures that policymakers have the means to measure and manage natural capital as part of broader economic strategies.

The consequences of environmental change ripple through economies via complex feedback loops. For instance, air pollution reduces labour productivity and competitiveness across all sectors and places pressure on health systems and their budgets. But it also induces regulations in the transport sector, with implications for infrastructure design and vehicle manufacturing. Much of macroeconomics is concerned with interactions across sectors and countries, but the link back to natural capital is relatively understudied.

Endogenous growth theory and theories of induced innovation and technical change highlight the scope for powerful positive and negative feedback dynamics (see Aghion et al., 2019). Depleting natural, physical and human capital (for example, where all three are linked through floods, droughts and water stress), undermines economic growth and thereby reduces the resources that are available for future investment. This lowers economic growth further. By the same token, efforts to enhance sustainability have been shown to lead to virtuous feedbacks, in the form of scale economies in production and discovery delivering a cleaner, more innovative and productive future. The future is not preordained; instead, it will be determined endogenously by the investment society makes along the way. The impact of this investment on comprehensive assets needs to be measured and accounted for.

Thus, application of the SEEA is not limited to environmental policy, but it is also about improving and expanding the evidence base for assessing wealth, directing investment across a broad portfolio of productive assets and managing risk across the entire economy. The integration of natural capital with other forms of capital makes the SEEA a powerful macroeconomic tool which can be used in assessing economic stability, informing fiscal policy and managing the low-carbon transition. Assessing performance against metrics is a precondition for showing that action to preserve natural capital is in a country's economic self-interest.

In recent years there has been an explosion of initiatives among macroeconomic policymakers to measure and value climate-related risks. Climate is the first part of the natural capital agenda to have attracted mainstream macroeconomic policymakers' attention. However, tackling the depletion of natural capital alongside mitigating climate change is essential to preserve the conditions for economic growth and well-being. This requires a large-scale structural transition in all economies, mobilizing all forms of capital, and providing opportunities for sustainable gains in productivity, competitiveness and growth.

Background

AUDIENCE

This paper is aimed at macroeconomic policymakers at various levels including international organizations and national governments, especially central banks and finance ministries. These stakeholders are currently some of the primary users of the System of Environmental Economic Accounts (SEEA), and this document will show how the SEEA can answer a variety of policy questions on sustainable macroeconomic strategies. This paper provides several successful examples that are aimed to inspire policymakers in applying the SEEA to inform strategies that ensure sustainable, long-term growth.

It is a misconception to think that the SEEA is, or should only be used by ministries of environment or policymakers working on environmental issues. Given that economies are reliant on multiple forms of capital - including natural capital - environmental issues are also economic issues. Macroeconomic policies stand to benefit from using the SEEA framework precisely because it uncovers the interrelationships between the environment and economy.

In addition to policymakers, this paper may be of interest to businesses, NGOs, insurance companies or members of the general public. For example, the corporate sector is increasingly adopting Natural Capital Accounting (NCA) in their decision-making processes in order to streamline business models and de-risk supply chains.[2] Citizens are also increasingly interested in how their investments will fare in the midst of a changing climate. The focus of examples in this paper are mainly on country-level applications that appeal to national governments, though some examples are also relevant to other stakeholder groups.

Also related to this issue paper is an overview paper of the applications of the SEEA and two separate issue papers on biodiversity and climate change policies, which are targeted towards more specific audiences. The issue papers on climate change and biodiversity are geared towards environmental policymakers who are interested in the value that the SEEA can bring to their domain. This paper is meant for finance ministries or central banks that want to understand both the short and long-term impacts of the environment on economic growth.

2 Although companies are adopting NCA it is not always done using SEEA methodology (see also Example 4). There are however efforts to find common ground so that the various approaches align (Spurgeon et al., 2018).

THE ENHANCA PROJECT

This paper is part of a series that has been developed by the project "EnhaNCA: Enhance Natural Capital Accounting Policy Uptake and Relevance" which provides materials to increase policymakers' understanding of policy applications of NCA according to the SEEA. The objective of the project is to address three shortcomings in the environmental and economic policy space:

(a) A lack of awareness by policy makers on the value added of NCA and how it can address policy needs;
(b) A lack of systemization of the potential applications of NCA; and
(c) A lack of compelling case studies on the impact of NCA policy applications.

ACKNOWLEDGEMENTS

The project has received generous support from the German Federal Ministry for Economic Cooperation and Development, implemented through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

This paper has been authored by Matthew Agarwala and Dimitri Zenghelis (Bennett Institute for Public Policy), under the guidance of an editorial board. The Editorial Board operated under the direction of Alessandra Alfieri and Jessica Ying Chan (United Nations Statistics Division) and included the following persons: Thomas Brookes (IUCN), Raffaello Cervigni (World Bank), Glenn-Marie Lange (World Bank), Wadzanayi Mandivenyi (Department of Environmental Affairs of South Africa), Stefano Pagiola (World Bank), Corli Pretorius (UNEP-WCMC) and Juha Siikamaki (IUCN), and was chaired by A.H. Kroese (Statistics Netherlands).

The authors and editorial board would like to acknowledge the inputs of Chloe Hill and Sarah K. Jones (Altus Impact) for their editorial and design services on this paper. The author and editorial board would also like to acknowledge the support and contributions of Nina Bisom and Johannes Kruse (GIZ) in producing this paper. Finally, the authors would like to acknowledge Diane Coyle, Marco Felici, Saite Lu and Julia Wdowin (Bennett Institute for Public Policy) for their helpful comments.

With funding from the

Federal Ministry
for Economic Cooperation
and Development

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Acronyms

BEA	Bureau of Economic Analysis (United States)
CGE	Computable general equilibrium
DNB	De Nederlandsche Bank
DNP	National Department of Planning (Colombia)
ECB	European Central Bank
ESG	Environmental, social and governance
GDP	Gross Domestic Product
GHG	Greenhouse gas
IMF	International Monetary Fund
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IO	Input-output
NCA	Natural capital accounting
NGFS	Network for Greening the Financial System
PSBS	Public sector balance sheet
QE	Quantitative easing
SDGs	Sustainable Development Goals
SAM	Social accounting matrix
SEEA-CF	System of Environmental-Economic Accounting - Central Framework
SEEA-EEA	System of Environmental-Economic Accounting - Experimental Ecosystem Accounting
SNA	System of National Accounts
TCFD	Taskforce on Climate Related Disclosures
UN	United Nations
UNCEEA	United Nations Committee of Experts on Environmental-Economic Accounting
WEF	World Economic Forum

1. INTRODUCTION

The goals, priorities and policy contexts in which finance ministries and central banks operate differ across countries, governments and time. Yet some crosscutting themes exist, such as: non-inflationary growth, competitiveness, and financial and fiscal stability. The ability to deliver these goals depends on a society's productive capacity, or in other words, its total capital stock. Macroeconomic strategies that encourage the efficient development and deployment of capital help create the conditions for global competitiveness, sustained growth and macro stability.

Modern economies employ multiple types of capital to generate output, including physical (e.g. infrastructure), financial, human, social[3] and natural capital. In combination, the stock of these capitals determines an economy's productive capacity: its inclusive wealth (Managi and Kumar, 2018). If this broadly defined wealth falls, so will future flows of output. Economic theory provides a clear wealth management rule: maintaining non-declining consumption (that is, sustainability) requires non-declining inclusive wealth. Because natural capital is a key ingredient of inclusive wealth, it must be considered in any wealth management strategy.

Accounting for natural capital is of direct relevance to macroeconomic policymakers for several reasons. The first is simply to ensure effective capital management: accounts reveal trends in the quantity, quality and value of capital assets and enable informed investment decisions. This is as true for natural as for any other forms of capital. A second interest concerns interactions between types of capital. Changes in natural capital affect the value of all other forms of capital in the economy and must be considered within any economic

[3] Social capital refers to the level of trust in others and society, including in courts, the police, and government, and enables societies to overcome collective action problems (Zenghelis et al., 2020).

strategy. Finally, by recording environment-economy interactions in a systematic framework, natural capital accounts expand the evidence base for economic analyses.

Natural capital is the only element of wealth that currently exhibits general global decline. Mounting environmental pressures impose direct costs on the economy, threatening macroeconomic performance and undermining past and future economic growth (IPBES, 2019). Extreme weather events affect shipping and transportation, sea level rise affects the value of coastal infrastructure, and the availability of renewable energy affects the value of fossil fuel assets and the related infrastructure. Studies have shown that functioning natural ecosystems generate social and economic value (Sukhdev et al., 2010; Costanza et al., 2014). As a result, measuring and monitoring natural capital - the resources, systems and services nature provides for human economic activity, such as food, air purification, nutrient cycling, materials and minerals - is a necessary part of achieving sustainable growth and inclusive well-being. Yet these benefits remain largely undervalued in mainstream economics with potential macroeconomic consequences. Well managed natural capital augments the value of all other capitals, reduces systemic environmental risk, and underpins a stable flow of benefits for people, business and the macroeconomy.

The System of Environmental Economic Accounting (SEEA) is the international statistical standard for natural capital accounting (NCA). Implemented by nearly 100 countries, the SEEA organizes information on environmental-economic interactions, uncovering trends, trade-offs and economic consequences arising from natural capital (mis)management. The accounts can be compiled in both biophysical and monetary values and their structure is compatible with official economic statistical standards, namely the System of National Accounts (SNA). In short, the SEEA provides the necessary evidence base for bringing natural capital into the realm of macroeconomic statistics, analysis and policy.

The remainder of this paper is structured as follows: Section 1 describes the conceptual basis for focusing on wealth. Section 2 relates the SEEA to the macroeconomic policy context. Section 3 shows how SEEA accounts can be used in practice. Finally, section 4 explains how NCA metrics are likely to become key to macroeconomic concerns and essential to the management of investor perceived risks and opportunities.

1.1. National Accounts and the Macroeconomy

The SNA provides the international statistical standard for collecting, organizing, and reporting measures of economic activity through an integrated set of macroeconomic accounts. The accounts and resulting indicators play a central role in developing policy, conducting research and government economic analyses, and evaluating performance.

By organizing and reporting data over time, the accounts provide the primary evidence base for investigating economic questions. It is therefore crucial for the development of sound policy that the accounts, currently available to policymakers, contain the most comprehensive set of information available.

National accounts are not merely passive descriptive tools. The very act of measuring the economy, and making decisions regarding what is and is not included in the accounts, can affect policy design and economic outcomes. Governments set targets based on macroeconomic statistics, such as growing gross domestic product (GDP) or making progress towards the Sustainable Development Goals (SDGs).[4] Rather than passively describing the economy from the viewpoint of an external observer, economic statistics actively shape the economy by altering behaviour and driving policy responses. Statistics thereby become the lens through which the economy is understood and planned. More specifically:

- National accounts condense a mass of information on the complex economic interactions of economic agents and sectors;
- National accounts statistics and concepts shape and modify perceptions about the national economy and how it works: policymakers, businesses and individuals change their behaviour in response to the picture they see through measurement;
- Policymakers are praised in the popular press and rewarded in the ballot box when they deliver against national accounts metrics like GDP;
- As the accounts are expanded, the understanding of the economy expands and policy preferences are influenced.

The role that national accounts play in providing evidence on the structure, productivity and performance of modern economies has earned them an influential role in policymaking. Not only are national accounts used to evaluate policy, but they are used in target setting and policy development as well. For instance, many indicators for measuring progress towards multiple SDGs are benchmarked to GDP.[5]

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[4] The SDGs comprise a number of goals and targets agreed by Member States and coordinated by the United Nations which provide a vision and future pathway towards enabling nations to better recalibrate how they value and manage their resources more effectively and sustainably. The SDGs were agreed upon in 2015. More information can be found here: https://sustainabledevelopment.un.org/

[5] To name just a few, indicators 1.5.2, 7.3.1, 8.9.1, 9.2.1, 10.4.1, 11.5.2, 12.2.2, 14.7.1, 17.3.2 and more.

1.2. Measuring Comprehensive Wealth

It is increasingly apparent that established macroeconomic statistics provide a partial view of modern economies. GDP measures flows of income, output and expenditure. But it does not measure the stocks that determine the capacity to generate such flows in the future.

On the other hand, the "wealth approach" focuses on the underlying capital stocks. These include not just tangible man-made assets, like physical and human capital, but also intangible assets like knowledge and social capital. These assets determine the capacity to generate future prosperity. Measuring and managing changes in wealth provides a deeper understanding of economic progress and improves economic resilience by containing risk. Natural capital accounts are part of a broader effort to better measure all assets as part of the comprehensive wealth story (Wealth Economy, 2019).

Wealth theory notes that future consumption and well-being depend on future productive capacity, which in turn depends on current net investment in capital (Nordhaus and Tobin, 1972; Weitzman, 1976; Arrow et al., 2012). It was initially developed to inform questions of environmental-economic sustainability. But the usefulness of wealth-stock measures (rather than just income-flow measures) is not limited to environmental analyses. The centrality of capital stocks to economic growth has been a cornerstone of economic theory and policy for more than a century (Fisher, 1904).

Defining comprehensive or inclusive wealth as the sum of all forms of capital (e.g. human, man-made, natural, social and intangible), provides a clear wealth management rule: endowing future generations with the potential to be at least as well off as the present; this requires, at a minimum, that comprehensive wealth is non-declining over time. This is a necessary, but not sufficient condition. If wealth falls over time, so must output.[6] Wealth accounts measure the extent to which individual countries adhere to the capital management rule (Pearce and Atkinson, 1993; Lange et al., 2018;

Managi and Kumar, 2018; Fenichel et al., 2018).

Wealth accounting entails three fundamental steps: definition, measurement and valuation. For physical capital, such as public infrastructure or manufacturing plants, there is already broad acceptance and application of consistent guidelines for each step. For natural capital, the SEEA is the agreed international statistical standard. The SEEA provides the framework for organizing and presenting statistics on the environment and its relationship with the economy. The SEEA-Central Framework (SEEA-CF) covers elements of natural capital (e.g. natural resources, including fisheries, timber, water, energy etc.) as individual environmental assets. The SEEA-Experimental Ecosystem Accounting (SEEA-EEA) complements the SEEA-CF to provide a measurement framework that focuses on how these individual assets interact over a given spatial area (see Annex for further information). The SEEA-EEA therefore takes a portfolio approach, recording the extent, condition and flows of services from ecosystem assets. The advantages of the SEEA lies in its consistency with the SNA, its authority as an international statistical standard and the way in which it organizes complex environmental-economic information.

Valuation of natural capital remains a significant challenge. The standard economic approach values capital as the net present value of all future flows of the benefits it generates. This is complicated by the fact that the value of any individual asset is a function of its interaction with other types of capital. This points to the need for balanced investment, noting that all assets are complimentary. For example, investment in human capital can improve individual health, life expectancy and build trust in communities and institutions, thereby boosting social capital. This improves productivity and enables investment in physical capital, training and governance, including improved environmental stewardship.

However, unlike other types of capital, natural capital, which provides the building blocks of all other capitals, is generally in decline. As a result, it poses one of the biggest threats to continued growth and prosperity. The air in cities has been severely polluted, soil and water degraded, and climate change is a growing and immense risk. These impacts, and the policy response to them, will shape the productive capacity of economies in the 21st century. Interactions between assets are crucial. Declining or depleted natural capital can undermine human health and well-being. Floods and natural catastrophes borne of environmental stress, impaired access to water and a changing climate, can destroy and disable physical assets and prompt social dislocation, including conflict and migration. Degraded social capital undermines the ability of human capital to generate new ideas, regardless of how well educated or trained people are and how well equipped their workplaces. Some forms of renewable natural capital, such as biodiverse and healthy ecosystems, forests and fish stocks, are prone to thresholds and systemic collapse when depleted. These critical natural assets are very difficult or impossible to substitute with other forms of capital in order to sustain well-being.

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6 The extent to which non-declining wealth is a sufficient condition depends on the degree of substitutability between specific types of capital. Given perfect substitutability, the non-declining wealth criterion is both necessary and sufficient. However, perfect substitutability is not realistic in practice – biophysical constraints, for instance, limit the degree to which water for crops can be displaced by human knowledge or physical infrastructure. Some elements of natural capital will face absolute limits to substitutability and are known as critical natural capital. If critical natural capital stocks fall below certain thresholds, no further substitutability is possible and even increases in other forms of capital cannot offset their loss.

photo : Jonaton Pie

1.3. Uncertainty in Measurement

The benefits of robust and standardized valuation are that it enables comparisons and trade-offs to be evaluated with a consistent numeraire, which is not possible in physical terms. Obvious applications include estimating future revenues from natural resources, as well as liabilities that may arise due to natural capital depletions.

There are, of course, limitations to wealth accounting, for example, as posed by the challenges in valuing capital. In principle, the net present value approach to valuing capital is already applied widely in economic measurement. For example, for a vehicle manufacturing plant, this entails discounting the market value of all future sales of vehicles to present terms. But many benefits from natural capital are not traded in formal markets and have no observable market price. More importantly, capital valuation is a forward-looking exercise and the time scales, over which capital is valued, differ across asset classes.

For short-lived capital such as a company vehicle, one can make informed judgements over the value of future services. But natural capital is much longer-lived and is also subject to greater uncertainty, which complicates the net present value calculation. Even for physical capital, valuation is not easy. That company vehicle could become a stranded asset[7] if emissions regulations change, rendering it un-roadworthy (see Box 2 in section 2.2. below on SEEA accounts for fossil fuels and renewables in the United Kingdom).

Forward-looking asset valuation is also complicated by changing expectations. The morning after a stock market crash, the factories, land, labour and ideas that generate output have not disappeared, but the expectation of their ability to generate benefits in the future has diminished. Yet these challenges do not prevent economists from developing capital accounts in which factories are recorded as assets. Even partial success in developing metrics while acknowledging what is missing, can help inform policy and business decisions.

There is concern among macroeconomists that natural capital is difficult to measure and value accurately. Concerns over valuation methods, future expectations (including the impact of non-linear tipping points such as biodiversity collapse or unsustainable fisheries), the availability of substitutes (e.g. renewable energy displacing fossil fuel assets) and changes in technology (e.g. irrigation technologies that affect the value of water resources) can all affect the value of natural capital. These uncertainties are compounded by the fact that natural capital is managed over the very long run. But, while elements of natural capital are more difficult to measure as well as value than other forms of capital, accounting for them is no less important. In fact, all capital valuation efforts entail making assumptions about an uncertain future.

Accounting for natural capital is complicated by several factors. The public good nature of many natural capital assets (e.g. a stable global climate) means there is often no obvious economic owner. Moreover, flows of ecosystem services (e.g. air purification, leading to clean air) are not exchanged in formal markets, making them harder to measure. However, substantial information about natural capital stocks and ecosystem service flows is available and could be used to inform wealth management decisions. Ignoring this information and omitting it from the accounting framework implicitly assigns a US$0 value to these stocks and flows. The World Economic Forum's (WEF) Global Risks Report consistently places natural capital related risks, such as climate change and ecosystem degradation, among the top five risks in terms of likelihood and impact, despite these being notoriously difficult to measure. While there is growing research on flows of "ecosystem services" or "climate change damages", the measurement of the stocks is severely underdeveloped (WEF, 2019).

The challenges encountered in valuing capital should not be understated. But neither should they be exaggerated. The approaches set out in the SEEA provide a sound basis for the definition, measurement and valuation of natural capital. For example, the SEEA-CF records flows of natural inputs into the economy (minerals, timber, fish, water etc.), the flow of products within the economy, and the flow of residuals going from the economy back into the environment (e.g. solid waste, air emissions, return flows of water) in both physical and monetary terms (see Annex). For monetary accounts, the valuation methods that are applied closely follow those used in the rest of macroeconomic statistics and in particular the SNA (Harris et al., 2019). To maximize the credibility, comparability and applicability of the accounts, valuation methods follow a set of common principles ensuring consistency in the concepts of stocks, flows and benefits, and how these are measured over time and across jurisdictions.

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[7] Stranded assets are assets that suffer abrupt write-downs, devaluations, or conversion to liabilities. For example, fossil fuel reserves are valuable assets in a fossil fuel-based economy, but could abruptly lose value if alternative energy sources dominate the market or governments enact strict climate policies to limit fossil fuel combustion.

1.4. A New Economic Strategy

Many of the concerns faced by macroeconomic policymakers surround issues of growth, productivity, competitiveness and the fiscal triangle (taxation, spending and borrowing). Making progress on any of these fronts requires sound capital management. Natural capital interacts with other forms of capital to generate output and determine national comparative advantages in global trade.

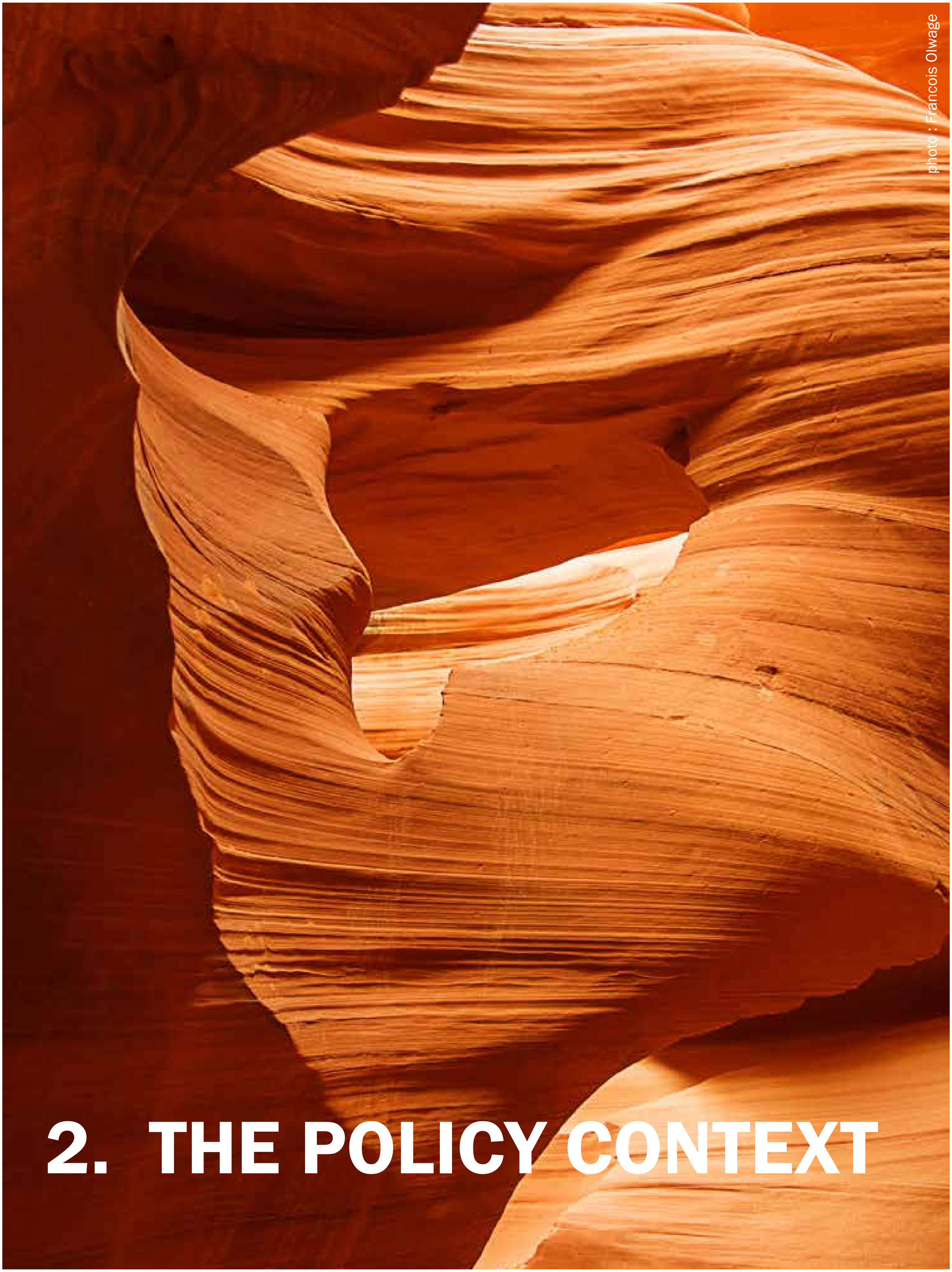
Changes in the composition, quality and spatial distribution of natural capital will impact the productivity of other factor resources. Thus, the SEEA is not merely a tool for improving environmental outcomes (though that is desirable), but also for improving the allocation and management of capital and expanding the evidence base for all economic decision-making.

Natural capital accounting is a necessary tool for macroeconomists to assess the relationships between different types of capital in the economy. Indeed, it is in this role that they may yield their greatest value added. Natural capital underpins economic activity by providing flows of material inputs, environmental goods and services, and by operating as a "sink" for waste assimilation and dilution. When these service flows are interrupted, for instance by floods, storms or species collapse, the rest of the economy suffers. Shipping and transport networks break down, imposing significant costs on just-in-time businesses, airports and railways close, and fishing communities deteriorate. Advances in environmental science and monitoring enable the development of the SEEA physical asset and flow accounts (which measure stocks of environmental assets and flows of environmental inputs and residuals, see Annex). Combined, these accounts provide information about the economy (natural capital) that decision-makers from the finance sector can use.

A critical benefit of the SEEA is that it uses a systems approach to organize economically relevant information in such a way that it can be integrated into macroeconomic analyses. This is because the SEEA follows the structure of the SNA. The advantage of the SNA is the way in which it organizes information about the macroeconomy. The supply and use tables of the SNA make it easy to see structural inter-sectoral relationships between industries, sectors, factors of production, sources of demand and institutional units.

By the same token, the SEEA also provides a systems approach towards assessing and conveying information. It organizes information about natural capital in way that is compatible with the SNA, meaning that these macroeconomic relationships can be extended – in accounting terms – to incorporate the natural environment. SEEA accounts provide these tables and record information on the use of natural capital throughout the economy, making them indispensable tools for understanding issues of capital management and allocation.

This makes possible a new approach to economic policy that addresses wealth management in an integrated and systemic manner. Just as produced and human capital can be included in macroeconomic models, the SEEA organizes natural capital information so that it can be readily incorporated into the models that governments already use on a regular basis. The result is that natural capital management can be "baked in" to all economic decision-making, in the same way that other forms of capital are done already. This has the potential to greatly enhance policy coherence.



2. THE POLICY CONTEXT

2.1. Macroeconomic Goals

Macroeconomic policy interests across the world vary widely, but almost all invariably include similar core objectives. These can broadly be categorized under the "fiscal triangle", "economic performance", and distribution, though these are clearly related. The fiscal triangle deals concretely with day-to-day management of government finances, and balances taxation, borrowing and spending (see Figure 1).

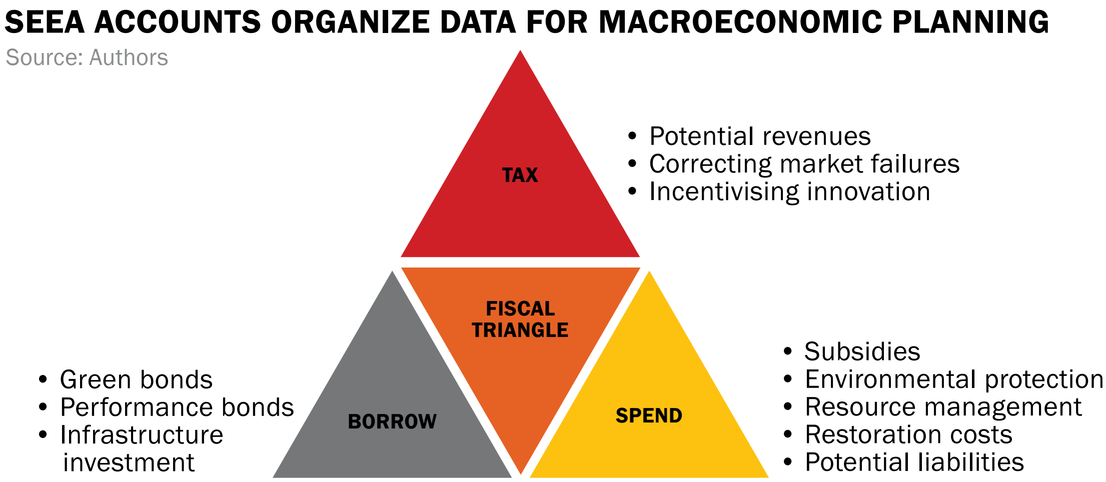
Questions of economic performance centre on the growth rate of the economy, underlying productivity, its competitiveness on the global stage and overall macroeconomic stability, which cover issues of exchange rates, resilience to shocks, and the prevention and management of crises (see Figure 2). The structure of the SEEA, and its coherence with the SNA, ensures that the accounts are directly applicable to these macroeconomic decision contexts.

Finance and treasury departments as well as ministries are charged with managing public finances. Their policies are designed to balance fiscal sustainability, maintain stable GDP growth and keep unemployment low. Resilience to macroeconomic shocks and system risks are also high priorities, as are fairness, inclusion and equality. To deliver these outcomes, policymakers must use a full suite of policy levers at their disposal, including taxes, subsidies, government borrowing, preferential treatment of capital in accounting systems, strategic investments in infrastructure and capacity building, as well as what are known as soft tools, such as providing signals through official statements. Direct fiscal policy options relating to natural capital revolve around carbon and pollution pricing, setting or regulating water tariffs, spending, procurement and investment, and public guarantees.

Figure 1 outlines how the SEEA augments fiscal decision-making. The SEEA includes environmental activity accounts, which reflect environment-related transactions between industries and households and governments (e.g. taxes and subsidies). The SEEA environmental activity accounts also organize information on environmental protection expenditures (e.g. on pollution reduction and abatement, waste treatment and disposal, biodiversity and landscape conservation, etc.) and resource management expenditures. These accounts enable decision-makers to assess the overall level of environmental protection and resource management expenditures in an economy, how they are changing over time, and who pays for them. Crucially, it enables finance and treasury ministries to anticipate future liabilities. This is important if we expect sea level rise to impact future coastal management costs, or deforestation and climate change to increase forest management costs (including fire prevention).

In addition, the SEEA accounts on environmental taxes can be used to inform strategies on the provision of public services (see Box 1 below). The SEEA not only clarifies the potential for tax revenues, but also for the use of fiscal policy to correct market failures and incentivize innovation, for instance towards a low-carbon economy. Finally, better understanding of environmental protection expenditures (Figure 1, lower right) has the potential to encourage innovation in green finance mechanisms and government borrowing (Figure 1, lower left). For instance, in 2019, the Netherlands became the first triple-A rated country to issue a green bond (US$ 6.68 billion) to fund 20 years of investment in clean transportation, climate adaptation, energy efficiency and flood management.[8]

Figure 1: *SEEA accounts and the fiscal triangle*



Box 1: *Using Water accounts to set water tariffs in Colombia*

Since the 1980s, deforestation and erosion has led to increased water scarcity in many of Colombia's small and medium-sized river basins. In response, the Government of Colombia introduced "water use fees" to raise funds for watershed management and restoration. A national minimum fee of 0.78COP/m3 was introduced, although regional authorities could increase this in their respective jurisdictions. This was a comparatively low fee (for example, it is only one fifth of the equivalent fee in Costa Rica), and by 2014 it became apparent that the fees were failing to raise enough revenue to support investments in watershed management and conservation. In fact, they failed even to raise enough revenue to cover the administrative costs of billing and collection.

The question then facing the Government was whether raising fees could achieve the objective of financing watershed conservation projects, and what impact this would have on various sectors of the economy. To assess this possible impact, the National Department of Planning (DNP) combined national water accounts with Colombia's existing social accounting matrix (SAM). By doing so, the DNP was able to model the macroeconomic impact of changes in the water use fee. As the SAM included all divisions of relevant stakeholders, it was also possible to conduct sectoral analyses. These analyses showed that increasing the minimum water use fees to 3COP/m3 and 10COP/m3 for agriculture and industry respectively would have negligible impacts on output and water abstractions, but would generate substantial funds for water management and watershed conservation investments.

Source: Vardon et al., 2017

[8] See: https://english.dsta.nl/subjects/g/green-bonds

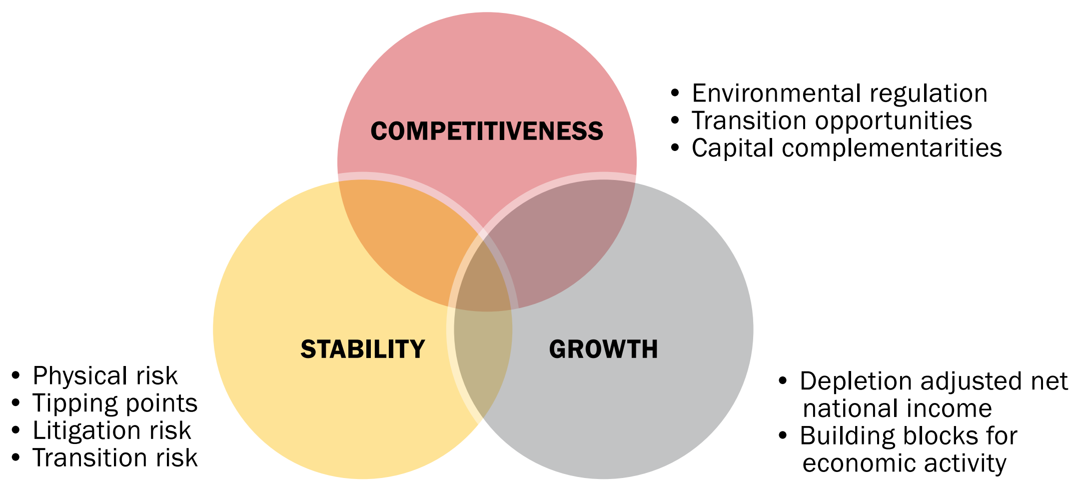
While the SEEA environmental activity accounts provide detailed information that can be used to augment fiscal decision-making, an equally important contribution is that they contain and organize information for developing broader economic strategies. Governments and economic institutions are equally concerned with macroeconomic stability, which is highly visible in the SDGs. This includes ensuring opportunities for decent work and economic growth (SDG 8) as well as building resilient infrastructure, promoting sustainable industrialization and fostering innovation (SDG 9). In particular central banks are also charged with managing inflation to ensure price stability, setting interest rates, and assessing financial risks and stability.

Figure 2 shows how the SEEA is a useful tool in this context. The accounts can help illustrate the effects of environmental regulation and innovation (e.g. transition technologies for a low-carbon future) on competitiveness. The accounts can also be used to calculate adjusted growth measures that factor in net investment in natural capital. By exposing potential risks and opportunities and linking these through to the rest of economic accounts, the SEEA provides decision-makers with a more comprehensive overview of the use, allocation and change in capital across the economy.

Figure 2: *SEEA accounts and macroeconomic performance*

SEEA ACCOUNTS CAN IMPROVE CAPITAL MANAGEMENT AND MACROECONOMIC OUTCOMES

Source: Authors



Natural capital depletion impacts both the fiscal triangle and macroeconomic performance. It enhances environmental risks, which translate to financial and macroeconomic risks in several ways.

1. Physical risk - which includes the costs of restoring natural capital, replacing ecosystem services, or adapting to depleted natural capital and addressing potential distress such as floods, droughts, natural disasters and ecosystem collapse;

2. Litigation liability risks - whereby people take to the courts to seek recompense and justice against private and public organisations who knowingly undertook activities which have undermined their livelihoods;

3. Transition risk - which focuses on disruption and valuation losses across the economy resulting from attempts to preserve or restore natural capital at an accelerated pace (see Box 3 in Section 4 below on stranded assets).

4. Financial risk - which arises when climate and environmental change undermines the returns to other assets (e.g. through physical risks), impacts the financial sector (e.g. insurance), or undermines investor confidence (see Box 4 in section 4.1 on climate-related risks in the Netherlands).

These risks have the potential to undermine productivity growth, stability and competitiveness, as well as undermine the fiscal triangle. For instance, air pollution impedes human capital generation and productivity, thus undermining global competitiveness. Tipping points and threshold effects can lead to abrupt shocks, such as fisheries collapse and extreme events, thus compromising stability. They also aggravate financial market risks in cases where market valuations shift rapidly in response to the realisation of some of these large-scale risks. Specific examples of these risks are discussed in Section 4 below.

It is not only an economy's absolute prosperity that matters to finance ministries, but also a country's position relative to its competitors. National level competitiveness and comparative advantages reflect shifts in technologies and markets. Economies that embrace change with diversified assets and flexible labour and capital markets, are more agile and better able to manage structural adjustment. For example, locking into fossil fuel-based infrastructures (e.g. coal power plants and car-based sprawling cities) increases the risk of these assets becoming stranded and starves low-carbon infrastructure of crucial investment. Such an economy will be ill-equipped for a world subject to mounting resource scarcity, competitive new technologies and markets, low carbon social behaviour, norms and tastes (including litigation against carbon emitters) and hostile policies.

2.2. Understanding the Public Sector Balance Sheet

Governments are beginning to develop extended public sector balance sheet (PSBS) accounts in order to better understand fiscal risks and add information to economic and fiscal outlooks. The goal of PSBS is to provide the most comprehensive picture of public wealth, bringing together accumulated assets and liabilities that governments control, including public corporations, natural resources, and pension liabilities (IMF, 2018).

Public sector net debt and public sector net financial liabilities are familiar measures to macroeconomic policymakers, but some governments (e.g. UK and New Zealand) are beginning to explore more comprehensive measures that incorporate natural capital.

Natural capital accounts are also important elements of the public sector balance sheet, which, if constructed well, can greatly improve fiscal outlook and policy (IMF, 2018). Complete PSBS can enrich fiscal policy by providing a more complete measure of public assets and liabilities (revealing opportunities for improved wealth management). This improves the identification of risks (including tail[9]-, transition-, and exchange-risks) and can improve fiscal policymaking by enabling a systematic and more comprehensive evaluation of the

[9] Tail risks refer to low probability, high impact events. Climate risks are sometimes referred to as "fat-tailed", describing the shape of the probability distribution curve in which much of the risk occurs at the low-probability end of the tails. The possibility of catastrophic climate damages, even with very low probability, justifies significant investment to combat climate change (Dietz, 2011; Pindyck, 2011; Weitzman, 2014).

impact of potential policies on public sector assets and liabilities (IMF, 2018). Using the SEEA in combination with a PSBS leverages the power of both. Sound balance sheet management facilitates increased revenues, reduced risks, and improved fiscal policy making. The IMF (2018) Fiscal Monitor, "Managing Public Wealth" argues that financial markets are increasingly paying attention to the entire government balance sheet and … strong balance sheets enhance economic resilience."

Natural capital accounts can improve balance sheet analysis in several ways:

- **A better understanding of liabilities:** Respiratory illness due to poor air quality can place a burden on the public finances either by reducing labour supply, reducing labour productivity, increasing burdens on publicly funded health systems or some combination of the three. The risk is particularly acute in aging societies. The SEEA air emissions account record particulate emissions by resident economic units and type of substance, which can be used to assess the overall public liability arising from air pollution.

- **A more accurate reflection of future revenue:** The SEEA environmental taxes account organizes data on public sector revenues from environmental taxation. These accounts can shed light on the reliability of current revenues, the potential for future revenues and the fiscal effect of asset stranding and other transition related risks (see Box 2 below).

- **A more accurate reflection of public sector net worth:** In most instances, government receipts from natural resources are treated as revenue, even when those funds come from the depletion of non-renewable natural capital. This overstates government revenues and inflates the net operating balance relative to the more accurate view that such depletions mimic the sale of non-financial assets. However, the SEEA records these depletions as reductions in wealth. Including natural capital stocks in the PSBS would help finance ministries and central banks ‘"stress test" environmental and technology scenarios around climate change and decarbonisation.

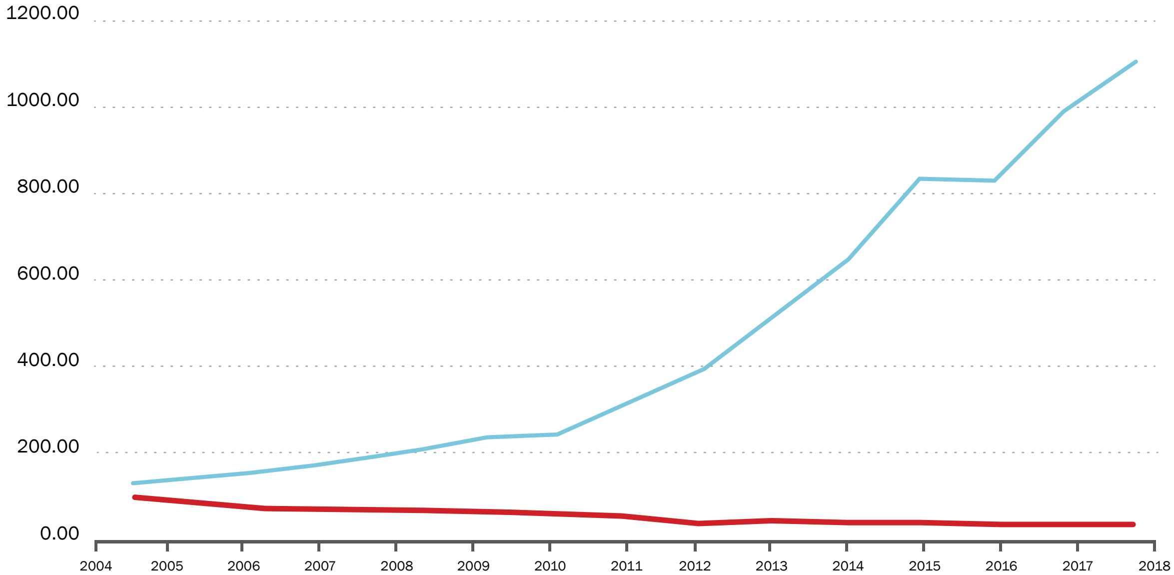
- **More effective institutions, policy frameworks and policies:** The impact of public policy in generating public goods, addressing market failures and internalizing externalities is increasingly important as natural capital is depleted. Policies which build broad assets, such as natural, social and other forms of intangible capital, in addition to physical infrastructure, yield direct and indirect returns to the government in the form of tax revenues from pricing externalities and higher future personal and corporate tax revenues that are generated through higher productivity.

Box 2: *SEEA accounts for fossil fuels and renewables in the United Kingdom*

The UK Office for National Statistics produces SEEA-CF and SEEA-EEA accounts. These accounts demonstrate important trends in the United Kingdom's stock of natural capital, flows of provisioning services, and implications for fiscal planning.

The figure below depicts relative changes in the physical flow of provisioning services from fossil fuels and renewable energy in the United Kingdom, from 2003 to 2018. Provisioning services from fossil fuels have fallen by 60 per cent, while those from renewable energy have risen by 1,000 per cent. In monetary terms, the value from fossil fuels still outweighs the value from renewables, but the direction of the trend is the same (the value of renewables is rising, while the value from fossil fuels is falling).

PHYSICAL FLOW OF PROVISIONING SERVICES, UNITED KINGDOM (2003 = 100)



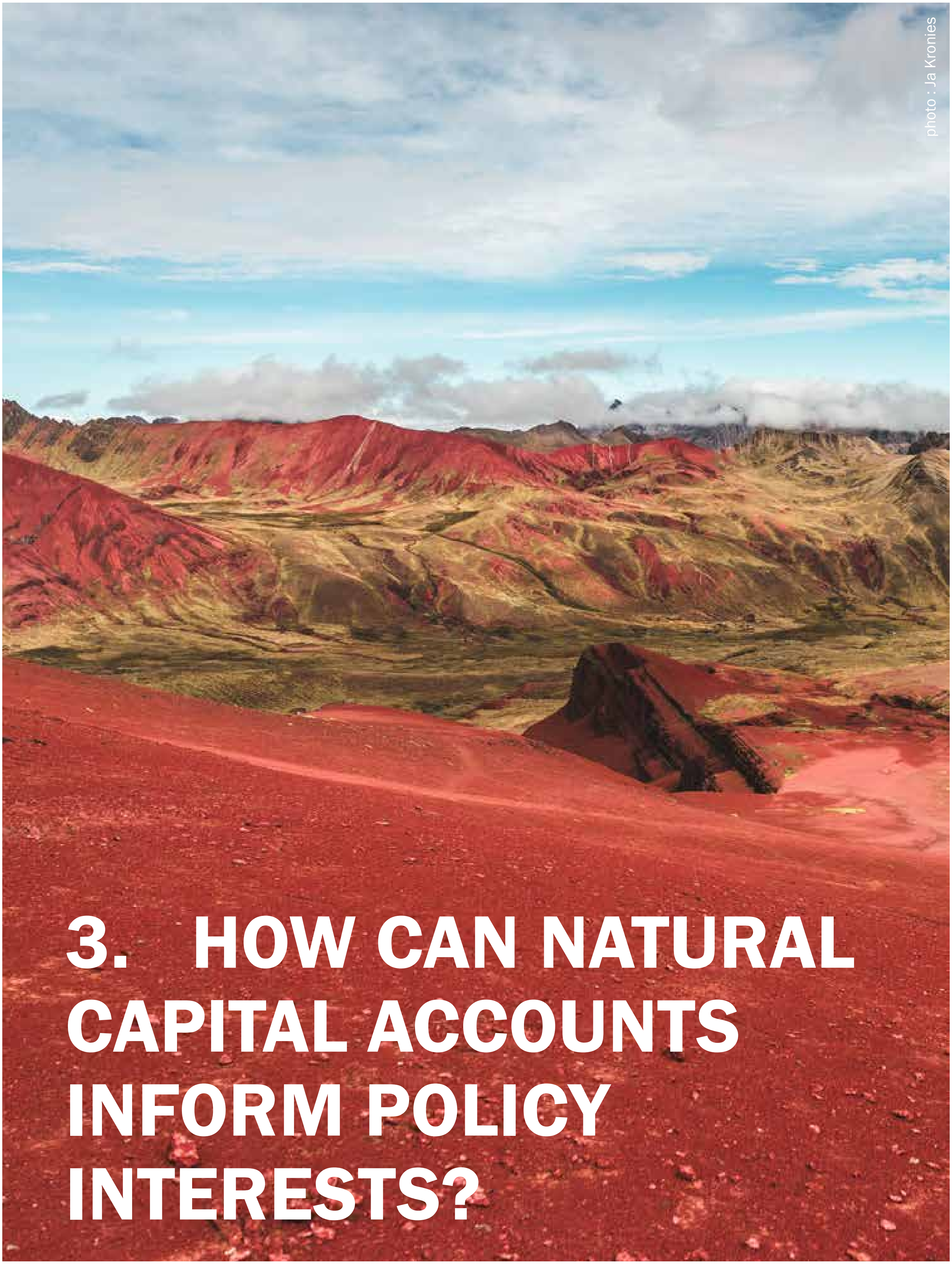
These trends have important implications for fiscal decision-making. The United Kingdom's SEEA accounts also show that environmental taxes raise £50.1 billion in revenue, or about 2.4 per cent of the United Kingdom's GDP. More than half (56 per cent) of this revenue arises from taxes on petrol, diesel, and other fuels used for transportation and heating.

As the United Kingdom's economy shifts towards renewables, the scope for raising tax revenues from fossil fuels will fall. The Treasury can use this information to develop long-term strategies for replacing lost revenues and maintaining fiscal stability.

Source: United Kingdom Office for National Statistics, 2019

The IMF's 2018 Fiscal Monitor focused on managing public wealth and notes that (i) public sector balance sheets have enabled economies to manage economic shocks, but that (ii) the treatment of natural resources, within public sector balance sheets, could be improved as they currently record natural resource depletions only as revenues rather than capital depletions. As more countries begin to produce public sector accounts, the treatment of natural capital within them will become increasingly important.

These public sector accounts are also useful for conducting intertemporal balance sheet analyses, which include the possibility of future taxation as a source of government revenue. This is a potential area where natural capital accounts could be particularly important, as environmental taxes may become more politically acceptable around the world.



3. HOW CAN NATURAL CAPITAL ACCOUNTS INFORM POLICY INTERESTS?

Many of the most important levers available to macroeconomic policymakers address the accumulation and management of capital. The SEEA's focus on natural capital and its consistency with the SNA mean they can be used alongside the rest of official economic statistics in guiding policy, evaluating its impact, and measuring progress.

Compiling the SEEA expands the evidence base for economic analyses. Economic models such as input-output (IO) models and computable general equilibrium (CGE) models are the basis of government economic analyses (see Annex for further details). They are the workhorse macroeconomic tools that are used to assess the effect that a wide range of stimuli (including shocks, crises, and new policies) can have on economic outcomes. They have earned this status for two mutually reinforcing reasons: their versatility and the availability of data for real-world applications.

3.1. Expanding the Evidence Base for Macroeconomic Models

Macroeconomic models measure both the direct effects of stimuli (say, a policy change) and the indirect, or "domino", effects as changes ripple through an economy. For example, in developing a national industrial strategy, a government might support a new auto manufacturing facility. It would be reasonable for the government to consider the direct effect – the cost of building the facility.

But it would be naïve of the government not to also consider the indirect effects, such as any jobs created in the supply chain, additional infrastructure investments that may be required to support those supply chains, impacts on housing stock and healthcare facilities as a result of new employment and/or the need for new schools, new teachers, and so on. Support for the auto industry initiates a ripple effect with impacts across many other sectors. Input-output models are adept at capturing these indirect effects.

Baumol (2000) notes that "with the introduction of the IO model, analysis of interdependence receives a new burst of freedom". This is because the IO model organizes data according to the structure of the economy, recording flows of outputs from one industry as inputs to another, and ultimately tracing the goods and services produced through to their final demand (typically households or governments). Thus, IO models highlight structural links between sectors, inputs and outputs in an economy. Capital has always been a key component of the IO table and model, and incorporating natural capital simply represents an extension.

At the heart of the IO model are IO tables that describe the flows of products from each industrial sector (as producers) to each of the other sectors, itself, and final consumers. By incorporating the flows of ecosystem services generated by natural capital into these tables, using information from the SEEA accounts means that the environment can be automatically included in all economic analyses. Rather than making environmental impact analysis an "add-on", this analytical approach makes sure that interactions between natural capital and the rest of the macroeconomy are built-in to mainstream macroeconomic tools (see Section 3.2 below).

3.2. Integrating Environmental-Economic Feedbacks

The benefit of developing SEEA accounts is that they provide an evidence base for measuring environmental-economic feedbacks and can help model the effect of changes as they ripple throughout an economy. Furthermore, their usefulness is not limited to environmental policy. The following example illustrates how natural capital accounts inform economic assessments well beyond the environment ministry.

The US healthcare sector represents about one fifth of the United States' GDP, or about US$3 trillion dollars. It is an energy intensive sector, as hospitals are among the most energy intensive buildings in the economy (they are open 24x7, require sophisticated heating, cooling, lighting, and ventilation systems, etc.). In addition to the direct impact of hospitals, the health sector produces resource and energy intensive pharmaceuticals, medical devices, single-use surgical equipment and toxic materials, including chemotherapeutic drugs and nuclear medicine. Using an IO model, Eckelman and Sherman (2016) showed that, in 2013, the healthcare sector was responsible for 12 per cent of US acid rain, 10 per cent of GHG emissions, 10 per cent of air pollutants, and 1 per cent of ozone depletion.

These pollutant flows from the health sector represent environmental degradation that can be recorded in the SEEA and attributed to the healthcare sector. The analysis becomes more useful to health and finance ministries when the effects of health sector pollution are linked to impacts on public health. Eckelman and Sherman estimate that 470,000 disability adjusted life years were lost in 2013 due to disease arising from US health sector emissions. Crucially, this includes the health impact of energy emissions generated by hospitals. The framework also enables a simple calculation of transition scenarios. The disease burden attributed to health sector emissions drops to 405,000 disability adjusted life years lost when adjustments are made for recent trends in cleaner energy production. Thus, US healthcare provision entails natural capital degradation that generates additional health burdens. Improving the sector's environmental performance could offer direct cost savings (in energy and waste reductions) and indirectly, through improved air, water and soil quality, and the associated reduction in the burden of disease.

Data for the analysis relied on IO models that were compiled by the United States Bureau of Economic Analysis (BEA), which describe monetary flows among 400+ economic sectors in the US economy. But to estimate the environmental (natural capital) impacts, sector-specific emissions intensities needed to be derived and were not available in the official BEA statistics. Moreover, the data only enables them to incorporate pollutant emissions to air, water and soil. Other natural capital impacts are not included.

However, compiling a full set of SEEA accounts would enable economic analyses to incorporate a greater range of natural capital impacts and feedbacks. Similar analyses would be possible for all sectors and in all countries that compile such accounts. Interactions could also be explicitly modelled. For instance, health effects on human capital and labour productivity will impact other sectors and these effects could be quantified. Table 1 elaborates the different contributions the SEEA can provide for macroeconomic decision making.

TABLE 1: CONTRIBUTIONS OF SEEA ACCOUNTS IN MACROECONOMIC DECISION CONTEXTS

DECISION CONTEXT	CONTRIBUTION OF THE SEEA
Capital management	• Provide a more complete measure of the overall capital stock and related flows of services through an economy • Integrate natural capital with the rest of economic statistics • Highlight trends and changes in natural capital stocks over time
Fiscal triangle	• Identify potential revenue sources (environmental taxes) and risks (if former revenue sources become stranded) • Clearly report environmental expenditures and facilitate budget planning
Public Sector Balance Sheets	• Provide a more comprehensive measure of assets owned • Demonstrate public sector net worth and improve the information for financial markets
Economic modelling	• Organize data so that natural capital is “built in” to standard economic analyses • Improve footprint analyses and assess resource security concerns • Explore environmental-economic synergies and trade-offs throughout economies
Green finance	• Assess whether green finance initiatives actually deliver environmental improvements • Provide an evidence base for monitoring green investments and performance • Regulatory tool for assessing environmental impact of green finance
Environmental reporting	• Agreed terms, definitions, and measurement strategies for international comparisons • Useful in reporting on international agreements (e.g. Paris Agreement) • Provide a basis for corporate reporting and environmental disclosure

Source: Authors

photo : Sylvain Cleymans

4. HOW THE SEEA CAN COMPLEMENT ONGOING INTERNATIONAL INITIATIVES IN GREEN FINANCE

There are a growing number of global initiatives and case studies that highlight the importance of coherently measuring and accounting for natural capital. Macroeconomists increasingly see the need to understand and explain the potential impact of environmental depletion, climate change, and the transition to a sustainable economy on productivity, financial stability, and fiscal and monetary policy. In line with the macroeconomic goals set out in Section 2.1 above, macroeconomists are concerned with physical, litigation liability and transition risks.

Physical risks from natural resource depletion and environmental degradation reflect the fact that economies will have to bear the cost of adaptation and a changing climate. This includes increased spending on: health costs related to air pollution, which account for one in eight of global deaths worldwide (Osseiran and Lindmeier, 2014); on environmental restoration of water and land ecosystems; on equipment such as air conditioning and resilient infrastructure such as seawalls; and so on. These costs would divert resources from innovation and technical change elsewhere in the economy, which could accumulate negative implications for productivity growth (Dietz and Stern, 2015).

For example, weather related insurance losses have increased almost seven-fold to an average of around US$68 billion per annum in the current decade from an average of around US$10 billion per annum in the 1980s, in constant 2018 prices (MunichRe NatCatSERVICE database). Economists are also concerned with the systemic risks to entire industries from mounting litigious claims. In October 2019, Massachusetts joined New York in suing Exxon Mobile for allegedly hiding its knowledge of climate change and misleading investors on its financial impact. Cities and counties in New York, California, Colorado, Washington and Maine have filed civil lawsuits against oil and gas companies. According to the latest Grantham Research Institute of the London School of Economics "Global trends in climate change legislation and litigation" survey, there are currently 25 climate-related lawsuits brought against governments or their representatives (Setzer and Byrnes, 2019). These lawsuits mark the start of a growing trend as companies and governments are found to have been knowingly supporting or undertaking activities which have resulted in damage to properties and livelihoods. Recently, the cases of PG&E[10] and Bayer/Monsanto[11] provide early examples of the power of litigation, or

10 See: https://www.barrons.com/articles/pg-e-stock-kincade-fire-wildfire-bankruptcy-51572027852)

11 See:https://www.spiegel.de/international/business/monsanto-merger-migraine-roundup-is-toxic-for-bayer-a-1247225.html

even the risk of litigation, to transform a business's viability. When such impacts are scaled up across an entire sector, the risks to macroeconomic stability can be large.

Macroeconomists are also increasingly concerned with the disruption that the transition to sustainability may cause, the more so if it is delayed and undertaken in a rush rather than managed appropriately. Industries, households and businesses are likely to be affected. But investors, in turn, increasingly recognize the strong economic and commercial case for investing in sustainability and preserving natural capital by divesting from risky, environmentally destructive, high-carbon sectors (Ralph, 2018). The disruptions that the transition to a low-carbon sustainable economy can bring, particularly when natural assets are not measured or monitored, are detailed in Box 3 below.

Box 3: *Stranded Assets*

A large-scale global transition to a low carbon, resource efficient and sustainable economy can generate "unexpectedly" rapid change, as technologies, social norms and institutions overcome inertia and shift to new networks of production and consumption. As awareness of opportunities prompts expectations to adjust, this can lead to tipping points and rapid network shifts in technologies and behaviours. New technologies and behavioural changes impart change the valuation of physical, human, intangible and natural assets. Those caught on the wrong side of this change, risk being saddled with stranded assets and uncompetitive, outmoded infrastructure.

For example, a low-carbon transition is likely to lead a substantial reassessment of asset values. On the one hand, up to a third of global oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain in the ground from 2010 to 2050 (McGlade and Ekins, 2015) if global emissions are to remain below 2 degrees above preindustrial levels. In addition, much "downstream" carbon-intensive infrastructure, such as refineries, transport infrastructure, carbon-intensive industries and power generation also risks being stranded (Pfeiffer et al., 2016). The concept of "unburnable carbon" (Carbon Tracker Initiative, 2013) highlights the risk of a carbon bubble caused by the financial exposure from stranded assets, which could be driven by policy, technological innovation or the investors' decisions.

On the other hand, it is likely that a number of natural assets will increase in value. This might cover essential and scarce minerals such as nitrogen, potassium and phosphorus, but perhaps more especially to the value of renewable assets such as forests, ecosystems and fisheries and the desire to protect them. Each of these is recorded in the SEEA accounts.

Such change in valuations is key to destroying and creating wealth. Failure to monitor the stock of natural assets increases the risk of financial loss and the locking in to stranded assets. This is a source of concern to finance ministries with mandates to promote growth and maximize revenue collection (see section 2.2). It also worries central banks concerned about the consequences of disorderly unwinding of asset holdings and consequent systemic risk or, at the national level, sovereign risk (see Task Force on Climate-related Financial Disclosures in Section 4.2).

4.1. Green Finance Initiatives Could Transform the Global Financial System

The WEF consistently lists climate and environmental change among the top five global risks in terms of both likelihood and potential impact. Investors, fund managers and regulators face growing pressure to "green" the financial system. Several initiatives are under way.

The Network for Greening the Financial System (NGFS) includes 54 central banks[12] that are committed to ensuring the resilience of the global financial system to climate risk. Collectively, they cover around 31 per cent of the world population and almost half of global GDP and global GHG emissions. Members of the NGFS are incorporating climate risks into stress tests for national banking systems, and are encouraging businesses and markets to report on emissions, exposure to climate risk, and produce climate-resilient business plans.

National and international institutions and investors are beginning to divest from fossil fuels. Norway's US$1 trillion sovereign wealth fund is divesting from coal producers, small oil and gas, and exploration and production companies[13], while the World Bank, International Finance Corporation and the multilateral development banks no longer fund coal. Similarly, the UN Principles for Responsible Investment have attracted 2000 signatories from institutions responsible for US$80 trillion in assets under management.

These initiatives reflect mounting concern among macroeconomic policymakers that natural capital depletion and environmental degradation will be a source of financial and macroeconomic risk. Following the 2019 Amazonian forest fires, 246 investors, representing US$17.5 trillion in assets, asked investee companies to eliminate deforestation from their supply chains (Pinzon et al., 2020). Measurement of natural resources and ecosystems therefore fall within the mandates of government, central banks, and financial system regulators and supervisors to ensure the macroeconomic and financial systems remain stable and resilient.

Markets are beginning to respond. Concern over stranded assets, reputational risk, and the scale of green infrastructure needed to meet the Paris Agreement targets have created both a supply and demand for "green finance", with green bonds emerging as the fastest growing segment of the global bond market.[14] The potential magnitude of green finance raises two key concerns/questions for macroeconomic policy makers: 1) do green investments actually deliver environmental improvements? And, 2) what regulations are needed to ensure a new, innovative and fast-moving financial sector (i.e. green finance) that delivers benefits rather than a green bubble and subsequent financial crash?

Green finance is a new and fast-paced area of the global financial system. It has an unprecedented potential to support a green transition, but without proper regulation, it could also introduce its own risks into the financial system. For instance, there is no

12 At the time of writing (early 2020).

13 See: https://www.theguardian.com/world/2019/mar/08/norways-1tn-wealth-fund-to-divest-from-oil-and-gas-exploration

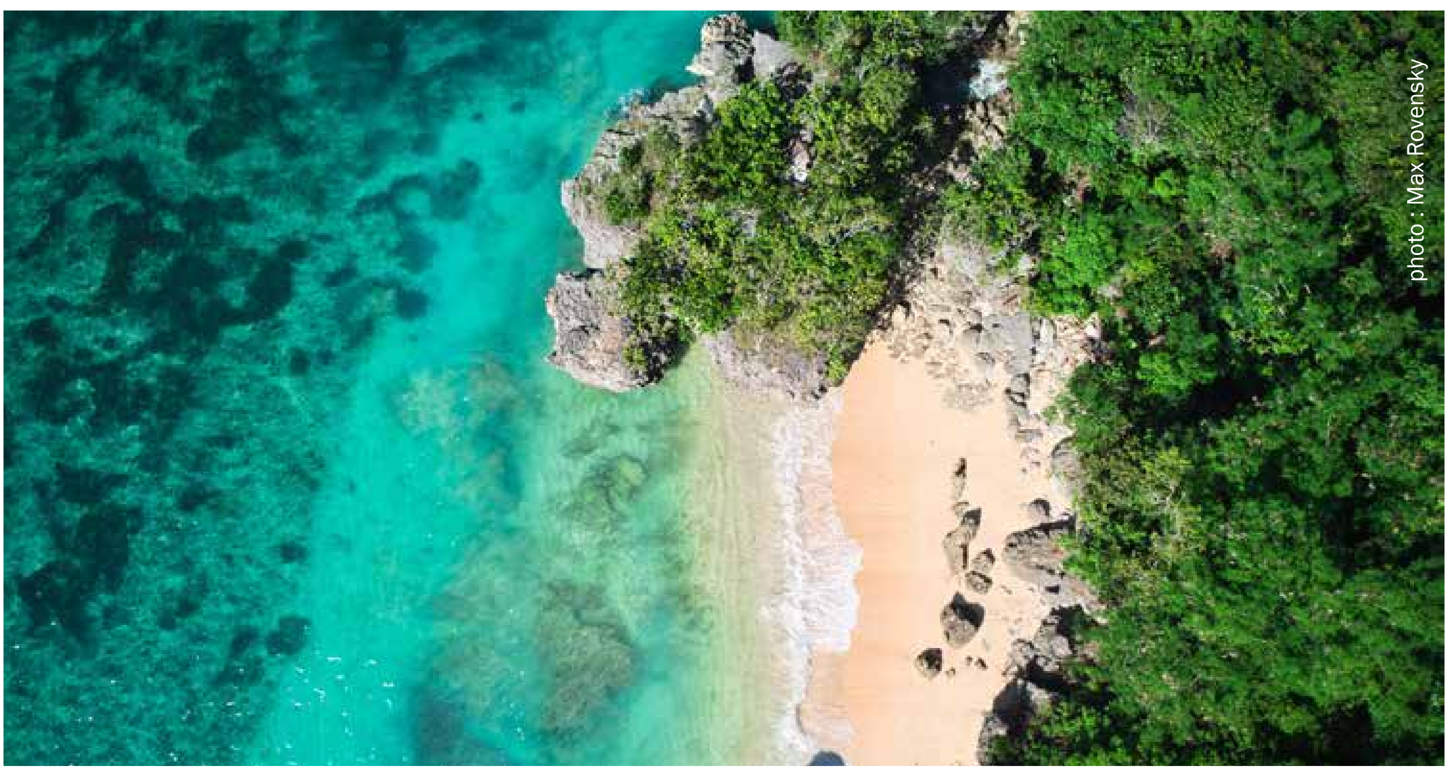
14 See: https://www.climatebonds.net/files/reports/2019_annual_highlights-final.pdf

current standard for labelling an investment as "green" (though may attempts to develop such a standard are under way), and without proper verification and validation, there is no way to assess whether green finance vehicles have actually delivered environmental improvement. SEEA accounts will be indispensable tools for assessing the environmental impact of green finance and, in combination with extended public sector balance sheet accounts, could be useful in directing financial flows to green investments (see Box 4 below). This is reflected in a growing appetite among institutional investors for metrics which help investors define and measure terms such as "impact", "green" or "zero carbon".

While the current version of SEEA links the environment and economy together from the perspective of production and consumption, there is a limited link between the environment and the financial accounts. The SNA does not distinguish green instruments, nor does it break the financial sector down into those institutional sectors whose primary objective is to facilitate the financing of green and sustainable activities. It is important that work begins in this area to develop the conceptual and practical infrastructure that would facilitate the dissemination of this information. Being able to quantify the flow of funds directed towards sustainable development is a necessary prerequisite towards understanding the macroeconomic and financial risk caused by environmental degradation and depletion, although the current measurement frameworks for the macroeconomy fall silent on this point.

However, by directly measuring natural capital stocks, their changes as well as their flows of services, SEEA accounts have the potential to provide an official statistical underpinning for a classification of green investments. An explicit classification of green investments is currently on the research agenda for the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA),[15] the intergovernmental body which oversees the overall coordination and prioritization in the field of environmental-economic accounting and supporting statistics.

[15] See: https://seea.un.org/content/un-committee-experts-environmental-economic-accounting-unceea



Box 4: *Climate-related risks in the Netherlands*

A recent report "Values at Risk" (Schellekens and van Toor, 2018) issued by the De Nederlandsche Bank (DNB), revealed that the Dutch financial sector is significantly exposed to climate-related risks. It argued that a higher incidence of extreme weather events can drive up insurance claims, and that lenders must respond to the implications of stricter regulations, such as mandatory energy efficiency requirements for office buildings and other properties.

It also pointed to other natural capital challenges reflected in the SEEA accounts. These include water stress, raw material scarcity and biodiversity loss. The study recommended that financial institutions translate ambition in the area of sustainability into their operational management. It explored how 25 large and medium-sized Dutch financial institutions integrate their sustainability ambitions into their operational management.

The DNB was also the first central bank to sign the United Nations' Principles for Responsible Investment in January 2019. It has launched a responsible investment charter, and is committed to incorporating six environmental, social and governance (ESG) criteria in its investment practices. The ecosystem accounts produced by the Netherlands can play a valuable role in responding to natural capital risks and challenges. The Netherlands has the most extensive ecosystem accounts in the world. The measurement of how investments impact the achievement of sustainability targets is still under development and is only occasionally applied, but coordination of approaches is likely to yield significant benefits. The report notes that many of the institutions surveyed say they are planning to develop impact measurements. The development of SEEA-based NCA accounting can complement and reinforce such efforts.

4.2. Monetary Policy and Natural Capital

A final source of concern among policymakers is the role of monetary policy in steering sustainable investment and changing risk profiles (either by ameliorating or enhancing risk), and the SEEA accounts can also play an important role here. The NGFS comprehensive report stated that the Network:[16]

> *'considers exploring the interaction between climate change and central banks' mandates (beyond financial stability) and the effects of climate-related risks on the monetary policy frameworks, paying due regard to their respective legal mandates.'*

So far, only the Central Bank of China has adopted a policy to support green finance through monetary policy. Several options exist within central bank mandates, for example in reflecting climate risks in large-scale asset purchase programs or collateral frameworks. Other interventions, such as green quantitative easing (QE) and credit allocation policies, are more controversial and are seen as violating monetary neutrality (whereby changes in the money supply only affect nominal variables and not real variables). A recent paper adopted a different argument for assessing the environmental impact of QE (Campiglio, 2017). The authors argued that QE should not provide additional support for green sectors, but rather that QE must be adapted to offset implicit biases in associated asset purchases through QE programmes which disproportionately support high carbon sectors. In other words, QE reform may be necessary to recreate a level playing field for investors.

The NGFS recommends that the appropriate public authorities develop tools and methods to identify and assess climate-related financial risks, and, whenever possible, make the data and assessment publicly available in a data repository. Such metrics will increasingly need to extend across all environmental assets, which have the potential to support or undermine future economic growth and the viability of key economic sectors. In assessing climate-related financial risks, the NGFS sees merit in setting up joint working groups, with interested parties (including, where applicable, central banks) to bridge the existing data gaps (NFGS, 2019).[17] Similarly, the Task Force on Climate-Related Financial Disclosures (TCFD) was established in 2015 by the Financial Stability Board to develop voluntary, consistent climate-related financial risk disclosures for use by companies, banks and investors in providing information to stakeholders.

By the same token, the NCA approach measures asset accounts for natural resources and ecosystems in a very explicit way, by valuing underlying assets based on the net present value of its expected future stream of benefits, and its distribution. In order to attribute value through NCA, it is necessary to conceptualize the dynamics of the environmental system in order to inform the policy process. The corresponding metrics need to be consistent, comparable, and decision relevant so that they can be readily incorporated into macroeconomic policy.

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16 See: https://www.mainstreamingclimate.org/publication/ngfs-a-call-for-action-climate-change-as-a-source-of-financial-risk/

17 The other NGFS recommendations are: integrating climate-related risks into financial stability monitoring and micro-supervision; integrating sustainability factors into own-portfolio management; building awareness and intellectual capacity and encouraging technical assistance and knowledge-sharing; achieving robust and internationally consistent climate and environment related disclosure; and supporting the development of a taxonomy of economic activities (NGFS, 2019).

5. CONCLUSIONS

The possibilities available to an economy in the future are a function of the decisions policymakers take in the management and stewardship of wealth today. The goals, challenges and policy levers encountered by macroeconomic decision-makers all entail solving capital management problems.

Sound capital management requires a robust evidence base for designing and evaluating broad strategies, specific policies and macroeconomic outcomes. Because natural capital is a fundamental component of wealth, this evidence base must include the most complete data available on natural capital stocks, their changes over time, and the exchange of goods, services, and residuals between the economy and the environment.

How we measure and manage our natural assets will play a key part in determining how much our economies can prosper. Monitoring natural assets can safeguard national economic strategies, guide forward-looking business plans, and help address many of today's pressing social and economic challenges. The SEEA, both the Central Framework and Experimental Ecosystem Accounting, provides a framework for developing the evidence base for managing natural capital within the modern economy.

One of the primary advantages of the SEEA is that its structure is compatible with the existing architecture for official economic statistics already in use around the world, the SNA. This means it is ready for integration with macroeconomic models already used by central banks, finance ministries and research agencies. Integrating SEEA accounts within standard macroeconomic analyses will provide a more accurate view of the structure of the modern economy, the role of important capital assets and the flow of services (including environmental services) throughout an economy. It enables macroeconomic policy and measurement to go "beyond GDP" without ignoring GDP.

Growth in GDP derived from depleting capital is unsustainable and deprives future generations of well-being. Whereas human, physical and knowledge capital may be growing, natural capital is generally in decline, with grave prospects for well-being. As markets, investors and regulators develop climate and environmental strategies to address the decline of natural capital, the SEEA accounts can be relied upon as a framework for assessing the impact of green investments. But their potential role is not limited just to impact evaluation. They can also be used to identify priority areas where financial capital can generate the highest environmental and economic returns. In this way, the SEEA accounts are not merely passive descriptions of the environment, they are tools for shaping the future of the economy.

REFERENCES

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Aghion, P., Hepburn, C., Teytelboym, A. and Zenghelis, D. (2019). Path dependence, innovation and the economics of climate change. In *Handbook on Green Growth*. Edward Elgar Publishing.

Arrow, K.J., Dasgupta, P., Goulder, L.H., Mumford, K.J. and Oleson, K. (2012). Sustainability and the measurement of wealth. *Environment and Development Economics* 17(03), 317–353.

Baumol, W. J. (2000). Leontief's Great Leap Forward: Beyond Quesnay, Marx and von Bortkiewicz. *Economic Systems Research* 12(2), 141–152.

Campiglio, E., Matikainen, S. and Zenghelis, D. (2017). *The climate impact of quantitative easing.* London: Grantham Research Institute on Climate Change and the Environment, London School of Economics. http://www.lse.ac.uk/GranthamInstitute/publication/the-climate-impact-of-quantitative-easing/.

Carney, M. (2019). *A new horizon* [speech]. https://www.bankofengland.co.uk/speech/2019/mark-carney-speech-at-european-commission-high-level-conference-brussels.

Carbon Tracker (2013). *Unburnable Carbon 2013: Wasted capital and stranded assets.* London: Carbon Tracker and Grantham Research Institute on Climate and the Environment, London School of Economics. http://carbontracker.live.kiln.digital/Unburnable-Carbon-2-Web-Version.pdf.

Costanza, R. et al. (2014). Changes in the global value of ecosystem services. *Global Environmental Change* 26, 152–158.

Davies, R. (2019). *Norway's $1tn wealth fund to divest from oil and gas exploration.* The Guardian, 8 March 2019. https://www.theguardian.com/world/2019/mar/08/norways-1tn-wealth-fund-to-divest-from-oil-and-gas-exploration.

Dietz, S. (2011). High impact, low probability? An empirical analysis of risk in the economics of climate change. *Climatic Change 108*(3), 519-541.

Dietz, S. and Stern, N. (2015). Endogenous growth, convexity of damages and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions. *Economic Journal* 125(583), 574-620.

Eckelman, M.J. and Sherman, J. (2016). *Environmental impacts of the U.S. health care system and effects on public health.* PLoS ONE 11(6), 1–14.

Fenichel, E.P., Abbott, J. K., and Yun, S. D. (2018). The nature of natural capital and ecosystem income. *Handbook of Environmental Economics, vol. 4*. Dasgupta, P., Subhrendu, K., Pattanayak, V. and Smith, K. (eds.). North-Holland Elsivier.

Fisher, I. (1904). Precedents for defining capital. *The Quarterly Journal of Economics* 18(3), 386–408.

Harris R., Reis S., Jones L., Agarwala M., Atkinson G. and Nowak D. (2019). *Discussion paper 4: Research paper on air filtration ecosystem services. Expert Meeting on Advancing the Measurement of Ecosystem Services for Ecosystem Accounting*. 22-24 January 2019. New York: United Nations Statistics Division. https://seea.un.org/events/expert-meeting-advancing-measurement-ecosystem-services-ecosystem-accounting.

Hoekstra, R. (2020). How Natural Capital Accounting Contributes to Integrated Policies for Sustainability. New York: United Nations Statistics Division.

IMF (2018). Fiscal Monitor: Managing Public Wealth. Washington, D.C., October.

IPBES (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Díaz, S., Settele, J., Brondízio E.S., Ngo, H.T., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K.A., Butchart, S.H.M., Chan, K.M.A., Garibaldi, L.A., Ichii, K., Liu, J., Subramanian, S.M., Midgley, G.F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Roy Chowdhury, R., Shin, Y.J., Visseren-Hamakers, I.J., Willis, K.J. and Zayas, C.N. (eds.). Bonn.

Lange, G.M., Wodon, Q., and Carey, K. (eds.) (2018). *The Changing Wealth of Nations 2018: Building a Sustainable Future.* Washington, D.C.: The World Bank.

Managi, S., and Kumar, P. (eds.) (2018). *Inclusive Wealth Report 2018: Measuring Progress Towards Sustainability.* London: Routledge.

McGlade, C. and Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2°C. Nature 517, 187-190.

MunichRe (2018). NatCatSERVICE, online data analysis tool. https://natcatservice.munichre.com/overall/1?filter=eyJ5ZWFyRnJvbSI6MTk4MCwieWVhclRvIjoyMDE4fQ%3D%3D&type=1. Accessed April 28, 2020.

NGFS (2019). A call for action: Climate change as a source of financial risk. https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf

Nordhaus, W.D. and Tobin, J. (1972). Is growth obsolete? E*conomic Research: Retrospect and Prospect* 5, 1–80.

Osseiran, N. and Lindmeier, C. (2014). *9 out of 10 people worldwide breathe polluted air, but more countries are taking action.* Geneva: World Health Organization. https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action.

Pearce, D., and Atkinson, G. (1993). Capital theory and the measurement of sustainable development: an indicator of “weak” sustainability. *Ecological Economics* 8(2), 103–108.

Pfeiffer, A., et al. (2016). The ‘2°C capital stock’ for electricity generation: Committed cumulative carbon emissions from the electricity generation sector and the transition to a green economy. Applied Energy 179, 1395-1408.

Pindyck, R.S. (2011). Fat tails, thin tails, and climate change policy. *Review of Environmental Economics and Policy* 5(2), 258-274.

Pinzon, A., Robins, N., McLuckie, M. and Thoumi, G. (2020). *The sovereign transition to sustainability: understanding the dependence of sovereign debt on nature.* London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, and Planet Tracker. http://www.lse.ac.uk/GranthamInstitute/publication/the-sovereign-transition-to-sustainability-understanding-the-dependence-of-sovereign-debt-on-nature/. Accessed April 2020.

Ralph, O. Insurers go cold on coal industry. *Financial Times*, 8 January 2018. https://www.ft.com/content/7ec63f34-f20c-11e7-ac08-07c3086a2625.

Schellekens, G. and van Toor, J. (2019). Values at risk? *Sustainability Risks and Goals in the Dutch Financial Sector.* The Hague: De Nederlandsche Bank. https://www.dnb.nl/en/binaries/Valuesper cent20atper cent20Riskper cent20-per cent20Sustainabilityper cent20Risksper cent20andper cent20Goalsper cent20inper cent20theper cent20Dutch_tcm47-381617.pdf.

Setzer, J. and Byrnes, R. (2019). *Global trends in climate change litigation: 2019 snapshot*. London: Grantham Research Institute on Climate and the Environment, London School of Economics. http://www.lse.ac.uk/GranthamInstitute/publication/global-trends-in-climate-change-litigation-2019-snapshot/.

Sukhdev, P., et al. (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.* Nairobi: United Nations Environment Programme. www.teebweb.org/our-publications/teeb-study-reports/synthesis-report.

United Kingdom Office for National Statistics (2019).UK natural capital accounts: 2019. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019#provisioning-services. Accessed 28 April 2020.

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and the World Bank (2014a). System of Environmental-Economic Accounting 2012--Central Framework. New York. ST/ESA/STAT/Ser.F/109

United Nations, European Union, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development and World Bank Group (2014b). System of Environmental-Economic Accounting 2012 Experimental Ecosystem Accounting. New York. ST/ESA/STAT/Ser.F/112

United Nations, European Union, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development and World Bank Group (2017). *System of Environmental-Economic Accounting 2012--Applications and Extensions.* New York. ST/ESA/STAT/Ser.F/114.

Vardon, M., Bass, S., Ahlroth, S. and Ruijs, A. (eds.) (2017). *Forum on Natural Capital Accounting for Better Policy Decisions: Taking Stock and Moving Forward.* Washington, D.C.: World Bank Global Program on Sustainability.

Wealth Economy (2019). *Measuring Wealth, Delivering Prosperity: The Wealth Economy Project on Natural and Social Capital.* Cambridge: Bennett Institute for Public Policy. https://www.bennettinstitute.cam.ac.uk/media/uploads/files/WER_layout_online_July_2019_final_doubles.pdf.

Weitzman, M.L. (1976). On the Welfare Significance of National Product in a Dynamic Economy. The *Quarterly Journal of Economics* 90(1), 156–162.

Weitzman, M. L. (2014). Fat tails and the social cost of carbon. *American Economic Review* 104(5), 544-46.

World Economic Forum (2019). *Global Risk Report.* http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

Zenghelis, D., Agarwala, M., Coyle, D., Felici, M., Lu, S. and Wdowin, J. (2020). Valuing Wealth, Building Prosperity. Wealth Economy Project first year report to LetterOne. Cambridge: Bennett Institute for Public Policy, University of Cambridge.

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Introduction to the SEEA methodology

The System of Environmental-Economic Accounting (SEEA) is the accepted international standard for natural capital accounting and provides a framework for organizing and presenting statistics on the environment and its relationship with the economy.

The SEEA framework follows a similar accounting structure as the System of National Accounts (SNA), which is the statistical standard to measure macro-economic transactions and flows. The SEEA framework uses concepts, definitions and classifications consistent with the SNA in order to facilitate the integration of environmental and economic statistics.

Two different perspectives are embodied in the SEEA. The first perspective is expressed through the SEEA-Central Framework (SEEA-CF), which looks at individual environmental assets such as energy, water, forests and timber, to explore how they are extracted from the environment, used in the economy, and returned to the environment in the form of waste, water and air emissions. The SEEA Central Framework allows for the integration of environmental information (often measured in physical terms) with economic information (often measured in monetary terms) in a single framework. The power of the SEEA Central Framework comes from its capacity to present information in both physical and monetary terms coherently. The SEEA-CF was adopted by the UN Statistical Commission, the apex body of the global statistical system, as the first international standard for environmental-economic accounting in 2012.

The second perspective complements the SEEA-CF by taking the perspective of ecosystems. The SEEA-Experimental Ecosystem Accounting (SEEA-EEA) looks at how individual environmental assets interact as part of natural processes within a given spatial area. The SEEA-EEA constitutes an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity. The SEEA-EEA was first drafted in 2012 and is now undergoing a revision, with the intention of reaching an agreement on as many aspects of ecosystem accounting as possible by the end of 2020.

SEEA-Central Framework

At the heart of the SEEA-CF is a systems approach to the organization of environmental and economic information which covers, as completely as possible, the stocks and flows that are relevant to the analysis of environmental and economic issues.

The SEEA-CF brings together, in a single measurement system, information natural resources, pollution and waste, production, consumption and accumulation. The SEEA-CF is composed of several subsystems which focus on specific areas of policy interest. For example, SEEA-Water is the conceptual framework and set of accounts which present hydrological information alongside economic information. SEEA-Water supports the analyses of the role of water within the economy and of the relationship between the environment and water-related activities, thereby supporting integrated water management. Other subsystems include agriculture, forestry and fisheries; air emissions; energy; environmental activity; land; material flow; and waste.

In practice, environmental-economic accounting includes the compilation of physical and monetary supply and use tables, functional accounts (such as environmental protection expenditure, taxes and subsidies accounts) and physical and monetary asset accounts. To assess how the economy supplies and uses natural inputs, SEEA accounts disaggregate flows by different units of production (industries as categorized by the International Standard Industrial Classification[18] and households). Data for SEEA accounts is usually collected from business and household surveys related to resource extraction and use.

SUPPLY AND USE TABLES

Supply and use tables in the SEEA-CF record the flows of natural inputs (e.g. flows of minerals, timber, fish and water), products and residuals (e.g. solid waste, air emissions and return flows of water) in both physical and monetary terms. In recording these flows, the SEEA-CF provides information on the amount and value of materials, water and energy that enter and leave the economy and flows of materials, water and energy within the economy itself. By providing information disaggregated by industries and households, supply and use tables provide valuable information on production and consumption patterns and changes in these patterns over time, as well as changes in the productivity and intensity of the use of natural inputs and the release of residuals.

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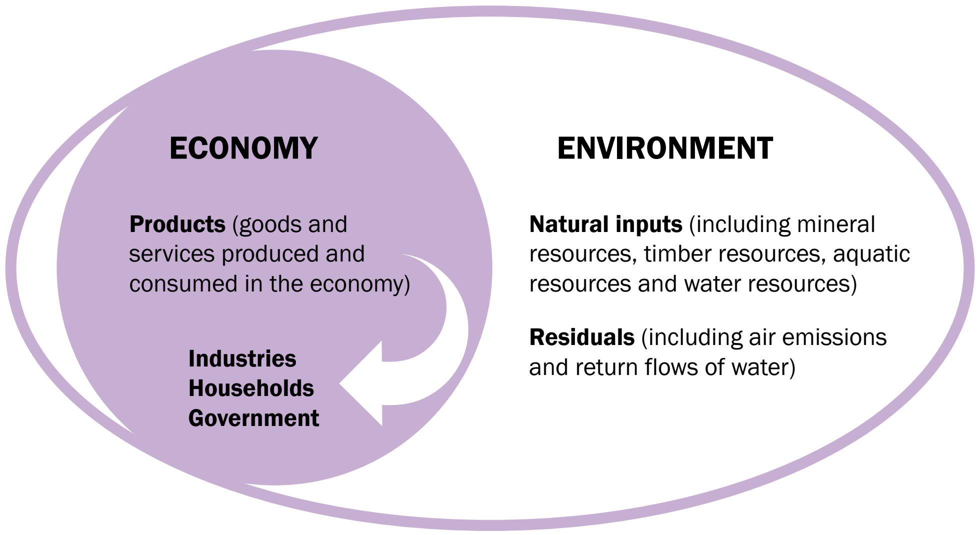
18 See https://unstats.un.org/unsd/publication/seriesM/seriesm_4rev4e.pdf.

Figure 1. *Physical flows of natural inputs, products and residuals*



Source: SEEA-Central Framework (United Nations et al., 2014a)

ASSET ACCOUNTS

Stocks and changes in stocks of environmental assets (e.g. water, timber, fish, minerals and energy resources etc.) are measured in the SEEA-CF through asset accounts. In physical terms, the Central Framework focuses on recording the physical stocks and changes of stocks of individual environmental assets, such as tonnes of coal, cubic metres of timber and hectares of land. However, the SEEA-CF also includes the measurement of stocks in monetary terms. The measurement of stocks in monetary terms focuses on the value of individual environmental assets and changes in those values over time. The valuation of these assets focuses on the net present value of the benefits that accrue to economic owners of environmental assets, and the use of monetary terms enables the analysis of trade-offs between the conservation and use of different natural inputs.

ENVIRONMENTAL ACTIVITY ACCOUNTS

Environmental activity accounts are a subsystem of the SEEA-CF which deserve special mention, as they do not focus on individual environmental assets, but transactions taken to preserve and protect the environment. More specifically, environmental activity accounts record transactions in monetary terms between economic units that may be considered for environmental purposes. Generally, these transactions concern activity undertaken to preserve and protect the environment or activity designed to influence the behaviour of producers and consumers with respect to the environment. Environmental activity accounts in the SEEA-CF include environmental protection and resource management expenditure accounts (which include, for example, direct expenditures for the protection of biodiversity), environmental goods and services sector accounts, and environmental taxes and subsidies accounts. Used in tandem with other SEEA accounts, environmental activity accounts supply valuable information on whether economic resources are being used effectively to reduce pressures on the environment and maintain the capacity of the environment to deliver economic benefits.

SEEA-Experimental Ecosystem Accounting

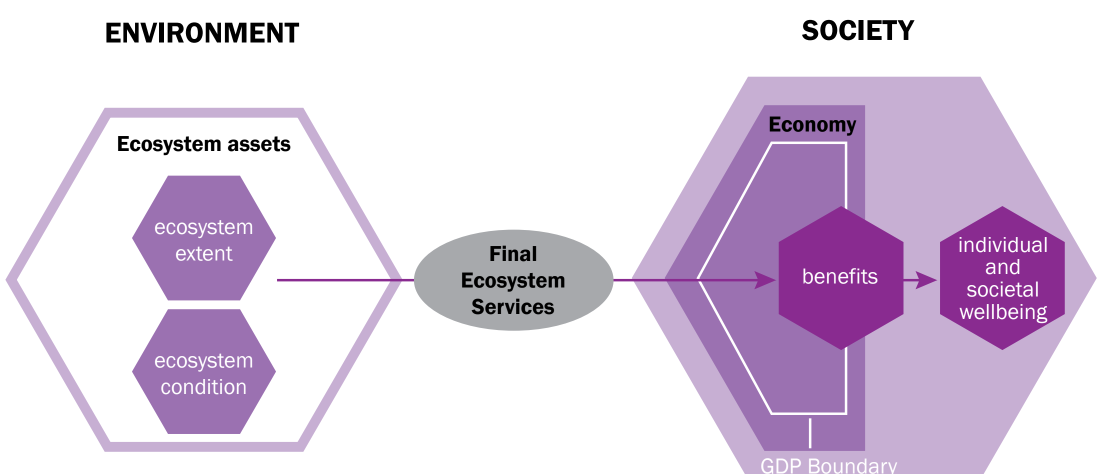
Fundamental to ecosystem accounting is the recognition that ecosystems are the source of goods and services that are essential to economic prosperity and human well-being, now and in the future. In the SEEA, an ecosystem is defined as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (United Nations et al., 2014b).[19]

Ecosystem assets are areas covered by a specific ecosystem type, such as forests, wetlands, agricultural areas, rivers, coral reefs etc. The contributions of ecosystems range from natural products such as timber and game to services like purification of air and water, pollination of crops, nutrient cycling, carbon storage and more. The importance of these services underlines the need for a thorough understanding of the ways in which ecosystems support economic and social well-being.

The framework, which is well aligned to national accounting principles, allows for the measurement of ecosystem assets in terms of both their condition (overall health) and the services they provide, and can be applied consistently across terrestrial, freshwater and marine areas. A defining characteristic of ecosystem accounting is that it is spatially explicit, i.e., it builds accounts based on underlying maps with information. As such, ecosystem accounting produces an integrated spatial information system.

Ecosystem accounting is based upon the conceptual model shown in Figure 2. The model starts with identifying ecosystem assets - an ecosystem that is mapped by mutually exclusive spatial boundaries such that each asset is classified to a single ecosystem type. Assets can be described through their condition and extent. Through intra-and-inter ecosystem flows, ecosystem assets generate ecosystem services – the contributions of ecosystems to benefits used in economic and other human activity, for example water regulation.

Figure 2. *SEEA-EEA Conceptual Model*



Source: UNSD

19 The SEEA uses the definition of the Convention on Biological Diversity. See https://www.cbd.int/ecosystem/description.shtml.

ECOSYSTEM EXTENT ACCOUNTS

Ecosystem extent accounts serve as a common starting point for ecosystem accounting. They organize information on the extent of different ecosystem types within a country in terms of area. In particular, ecosystem extent accounts describe the environment in terms of sets of mutually exclusive (i.e. non-overlapping) ecosystem assets. These assets (e.g. an individual forest, or a specific wetland) can be classified in terms of different ecosystem types such as forests, wetlands, cropland etc. All assets together populate an ecosystem accounting area, which could range from a watershed to a municipality to a country etc. The extent account describes the various types of ecosystems that are distinguished within an area and how they change over time.

ECOSYSTEM CONDITION ACCOUNTS

Condition accounts measure the overall quality of an ecosystem asset and capture, in a set of key indicators, the state or functioning of the ecosystem in relation to both its naturalness and its potential to supply ecosystem services. Essential is that the condition account compares at least two different years to track changes over time. As with all ecosystem accounts, condition accounts are built up from underlying maps of the various variables. For every ecosystem type (e.g. forest; inland water bodies etc.), a reference level is provided against which values for indicators can be compared. There is a wide range of indicators that can be assessed in the condition account, and indicators can be ecosystem type specific. Condition accounts provide valuable information on the health and state of ecosystems and their capacity of ecosystems to deliver critical ecosystem services in the future.

ECOSYSTEM SERVICES ACCOUNTS

This set of ecosystem accounts measures the supply of ecosystem services as well as their corresponding use and beneficiaries, classified by economic sectors used in the national accounts, in both physical and monetary terms. In SEEA EEA, ecosystem services are defined as "the contributions of ecosystems to benefits used in economic and other human activity" (United Nations et al, 2014b). SEEA EEA uses the following three broadly agreed categories of ecosystem services:

- Provisioning services (e.g. supply of food, fibre, fuel and water);
- Regulating services (related to activities of filtration, purification, regulation and maintenance of air, water, soil, habitat and climate); and
- Cultural services (related to activities of individuals in, or associated with, nature, such as recreation).

Ecosystem services are defined in SEEA EEA as the contribution to benefits, rather than as the benefits themselves, in order to avoid double counting. For example, an agricultural crop such as corn or maize is already recorded in the national accounts. Moreover, corn is the result of combining human capital (in the form of labour), produced capital (machinery) and natural capital (the cropland). The objective of the services accounts is to isolate the contributions of nature to the production of the crop visible. In addition, by expanding the national accounts production boundary, the accounts also recognize a range of ecosystem services that lead to benefits that are not currently recognized in the SNA such as carbon sequestration or air filtration.

MONETARY ASSET ACCOUNT

The monetary asset account records the monetary value of opening and closing stocks of all ecosystem assets within a given ecosystem accounting area, as well as additions and reduction to those stocks. The ecosystem services supply accounts are a key input into the monetary asset account and provide an estimate of the total annual flow that is generated during a specific year. The value of the ecosystem assets can be estimated by capitalizing these annual flows of services over the projected period i.e. the expected lifetime of the ecosystem, using a so-called net present value method. In order to estimate these projected service flows, it is important to take into account the capacity of the ecosystems to sustain these service flows which will depend on their condition and the extent to which these ecosystems are sustainably managed, and if not, make corrections to future service flows. Thus, the valuation of ecosystem assets allows an assessment of a more comprehensive measure of wealth of a country (in addition to produced capital, financial capital etc.).

THEMATIC ACCOUNTS

The SEEA-EEA also includes several thematic accounts. These are standalone accounts, or sets of accounts, that organize data according to an accounting framing about themes of specific policy relevance. For example, species accounts in the SEEA-EEA have the structure of an asset account and describe the opening and closing stock of a particular species over a period of time. The account tries to explain the observed changes in a number of categories (e.g. additions / reductions). The account can be compiled for instance for endangered species or for specific iconic species.

Carbon accounts are another common thematic account. The carbon account was developed to allow for a consistent and quantitative comparison of carbon stocks and flows in the reservoirs 'biocarbon' (organic carbon in soils and biomass), 'geocarbon' (carbon in the lithosphere), atmospheric carbon and carbon in the economy. Other potential thematic accounts include accounting for protected areas, wetlands and forests.

Aggregates and indicators

The SEEA-CF and SEEA-EEA are multipurpose and relevant in a number of ways for policy development and evaluation, as well as decision-making. First, the summary information (provided in the form of aggregates and indicators) can be applied to issues and areas of the environment that are the focus of decision makers. For instance, the SEEA-CF and SEEA-EEA provide the data to inform 40 SDG indicators, including goals 2, 6, 7, 8, 9, 11, 12, 14 and 15.

Second, the detailed information, which covers some of the key drivers of change in the environment, can be used to provide a richer understanding of the policy issues. For example, the SEEA-CF accounts can be effectively communicated to users and decision makers through combined presentations combining physical and monetary data. A combined presentation thus represents an analytical framework showing which parts of the economy are most relevant to specific aspects of the environment, and how changes in the economic structure influence the environment (see Figure 3).

Figure 3. *Possible structure of and typical content for combined presentations*

	Industries (by ISIC divisions)	Households	Government	Accumulation	Flows with the rest of the world	Total
Monetary supply and use: flows						
(currency units)						
Supply of products						
Intermediate consumption and final use of products						
Gross value added						
Depletion-adjusted value added						
Environmental taxes, subsidies and similar transfers						
Physical supply and use: flows						
(physical units)						
Supply of:						
Natural inputs						
Products						
Residuals						
Use of:						
Natural inputs						
Products						
Residuals						
Asset stocks and flows						
Closing stocks of environmental assets (currency units and physical units)						
Depletion (currency units and physical units)						
Closing stocks of fixed assets (currency units)						
Gross fixed capital formation (currency units)						
Related socio-demographic data						
Employment						
Population						

Note: Dark grey cells are null by definition

Source: SEEA-Central Framework (United Nations, 2014a).

Further, as the accounts provide consistent environmental and economic indicators, the possible trade-offs in environmental terms between alternative environmental and economic strategies can be analysed. The SEEA enables the calculation of indicators on several topics, including: resource use and intensity; production, employment and expenditure related to environmental activities; environmental taxes and environmental subsidies; and environmental assets, wealth, income and depletion of resources.

The SEEA also enables the derivation of depletion-adjusted balancing items and aggregates within the sequence of economic accounts of the SNA. Using the SEEA, balancing items, within the sequence of economic accounts, can be adjusted for depletion so that estimates of the monetary cost of using up natural resources can be deducted from conventional economic aggregates, such as GDP and saving to yield depletion-adjusted aggregates.

Applications of the SEEA

There are several other applications of the SEEA.[20] One common application of the SEEA is environmentally extended input-output tables (EE-IOT). EE-IOT are datasets that combine information from economic input-output tables from the SNA in monetary units and information on environmental flows, such as flows of natural inputs and residuals, that are measured in physical units.

EE-IOT data sets, which reflect industry and product detail in physical and monetary terms and encompass economic and environmental information, can be powerful tools in analysis and research. Input-output analysis is regularly used to attribute environmental flows to final demand categories. It can identify the link between final demand and resource use, emissions and other environmentally related flows and thereby highlighting "hot spots" or "pressure points" that are highly policy relevant.

The SEEA is also often used for decomposition analysis, a tool which enables separate estimates of the particular drivers influencing changes in environmental impacts or pressures. Since changes in the pressures from the environment occur within dynamic systems of interactions, it is often difficult to identify the extent to which specific consumption and production activities have contributed to changes in environmental impacts or pressures. Decomposition analysis can be used to account in detail for the factors underlying these changes. Typically, the variables used in the calculations include changes in the size of the economy, changes in the structure of the supply chain and demand, changes in the energy intensity of production, and improvements in the production process. Decomposition analysis can be used to understand, for example, the economic or technological changes that have caused emissions of CO_2 to increase. Thus, decomposition analysis can be a powerful tool for analysis and policy design.

Finally, another common application of the SEEA is computable general equilibrium (CGE) models. CGE models are a class of economic models that combine use of input-output data with the application of microeconomic theory and are especially well suited to analysing the future effects of policies. They consist of a system of non-linear demand, supply and market

[20] See The System of Evnironmental-Economic Accounting 2012 Applications and Extensions, https://seea.un.org/sites/seea.un.org/files/ae_final_en.pdf.

equilibrium equations, into which various assumptions may be introduced (depending on the model). In the context of the SEEA, CGE models may be developed using information contained in EE-IOT, thus bringing together monetary and physical data. The use of CGE models can facilitate an understanding of what dynamic impacts may be expected in the case of policy interventions, or other developments. For example, CGE models can assist in understanding the dynamics arising from the introduction of a tax on CO_2 emissions, which will entail a shift away from relatively carbon-intensive inputs.

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