DRAFT

System of Environmental Economic Accounting

NATURAL CAPITAL ACCOUNTING FOR INTEGRATED CLIMATE CHANGE POLICIES

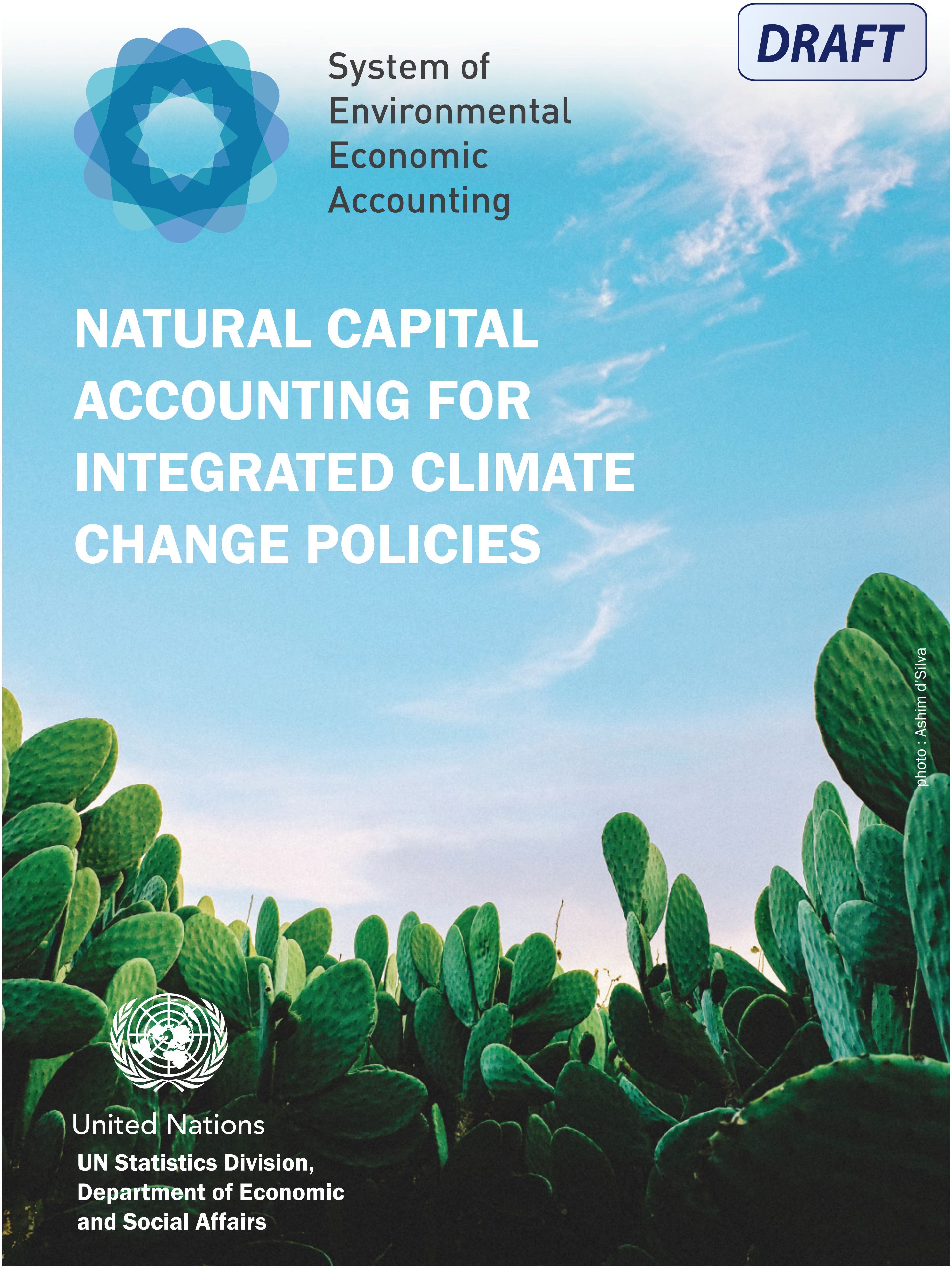

photo : Ashim d'Silva

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EXECUTIVE SUMMARY

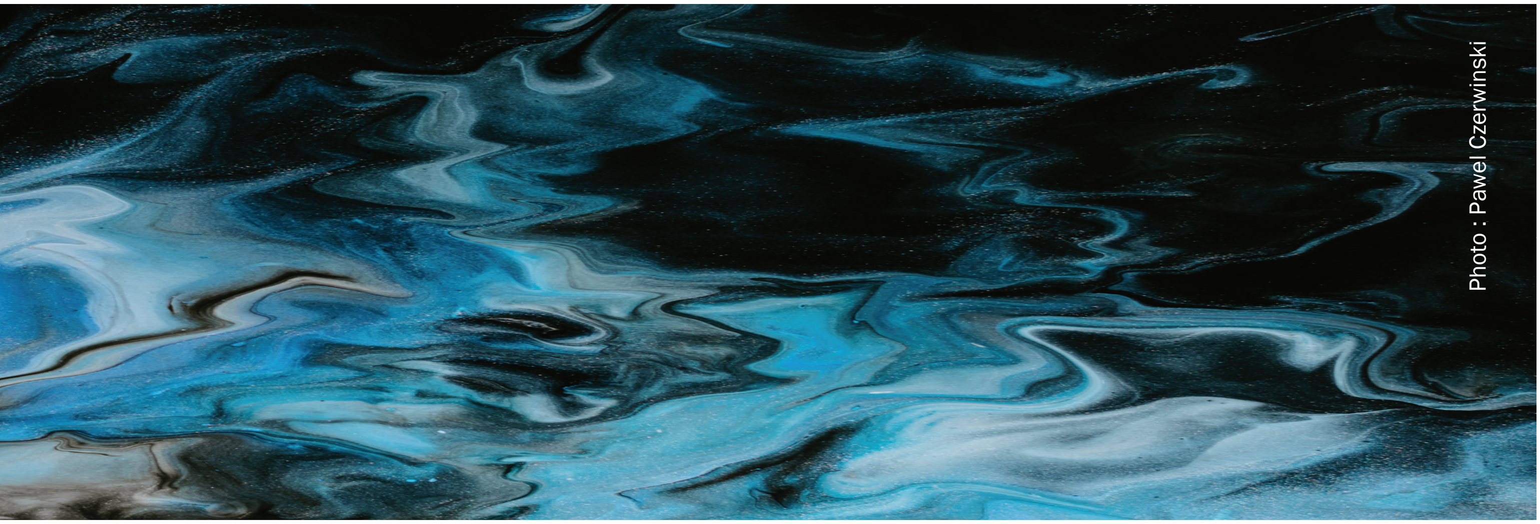
Climate change has been recognized as one of the most defining global issues of our time. The world is now at a pivotal moment where decision-makers need to decide to either address this situation head-on or to continue business as usual.

Indeed, if the goal of limiting temperature increase to 1.5 degrees Celsius under the Paris Agreement is to be met, it would "require rapid and far-reaching transitions in energy, land, urban and infrastructure... and industrial systems" (IPCC, 2018). This means that climate change is not just an environmental problem, but also an economic and social one. Therefore, in order for climate change policy to be effective, it must also be wide reaching.

As climate change is essentially associated with human activity that either increases greenhouse gas emissions and/or drives land use change, addressing climate change requires understanding as well as tackling the drivers that cause it, particularly the economic drivers. Understanding climate change in the context of the interrelationships between the environment and economy can not only facilitate a complete understanding of the drivers and impacts of climate change but also, and perhaps more significantly, identify and implement the necessary policy responses.

Countries will face the effects of climate change directly by implementing various mitigation and/or adaptation policies. But climate change is so pervasive, and its impacts so ubiquitous, that even those countries that do not intentionally respond to climate change specifically, will do so indirectly. For example, this may be via implementing actions or policies in response to the effects of climate change, such as natural disasters, forest fires, water scarcity, reductions in agricultural productivity or mass migration. Thus, policymakers from all policy domains, and at all levels, will need access to data that can support an integrated approach to climate change that also considers the interlinkages between environment and economy.

To this end, the international statistical community has developed an international statistical standard for natural capital accounting (NCA) called the System of Environmental-Economic Accounting (SEEA), which is an integrated framework that shows the relationship between the environment and the economy.



By providing a multipurpose view of the interrelationships between the economy and the environment, the SEEA can help understand the drivers and impacts of climate change.

Importantly, the SEEA can also provide information on the effectiveness of policy responses to climate change, which is essential for meeting the targets under the Paris Agreement. In short, the SEEA reveals the economy's impact on the climate and helps to identify which policies can be implemented to address drivers of climate change, while at the same time continuing to manage the economy effectively. As the examples in this paper demonstrate, data derived from the SEEA provide a valuable complement to emissions inventories and play an important role in understanding which "rapid and far-reaching transitions" governments should focus on, without damaging the economy. The SEEA provides this information through policy-relevant indicators as well as through supporting analytical and modelling techniques that can be used to assess the full impacts of climate change and policy responses.

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.[1] 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.

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[1] 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, as well as the three separate issue papers, are part of a series of papers developed by the project "Enhance Natural Capital Accounting Policy Uptake and Relevance (EnhaNCA)". The aim of the project is to provide materials to increase policymakers' understanding of 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.

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Acronyms

CO_2	Carbon dioxide
CES	Conference of European Statisticians
CGE	Computable general equilibrium
EE-IOT	Environmentally extended input-output tables
GDP	Gross domestic product
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
NCA	Natural capital accounting
NDCs	Nationally Determined Contributions
NGO	Non-governmental organization
SDGs	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SEEA CF	System of Environmental-Economic Accounting - Central Framework
SEEA EEA	System of Environmental-Economic Accounting - Experimental Ecosystem Accounting
SNA	System of National Accounts
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

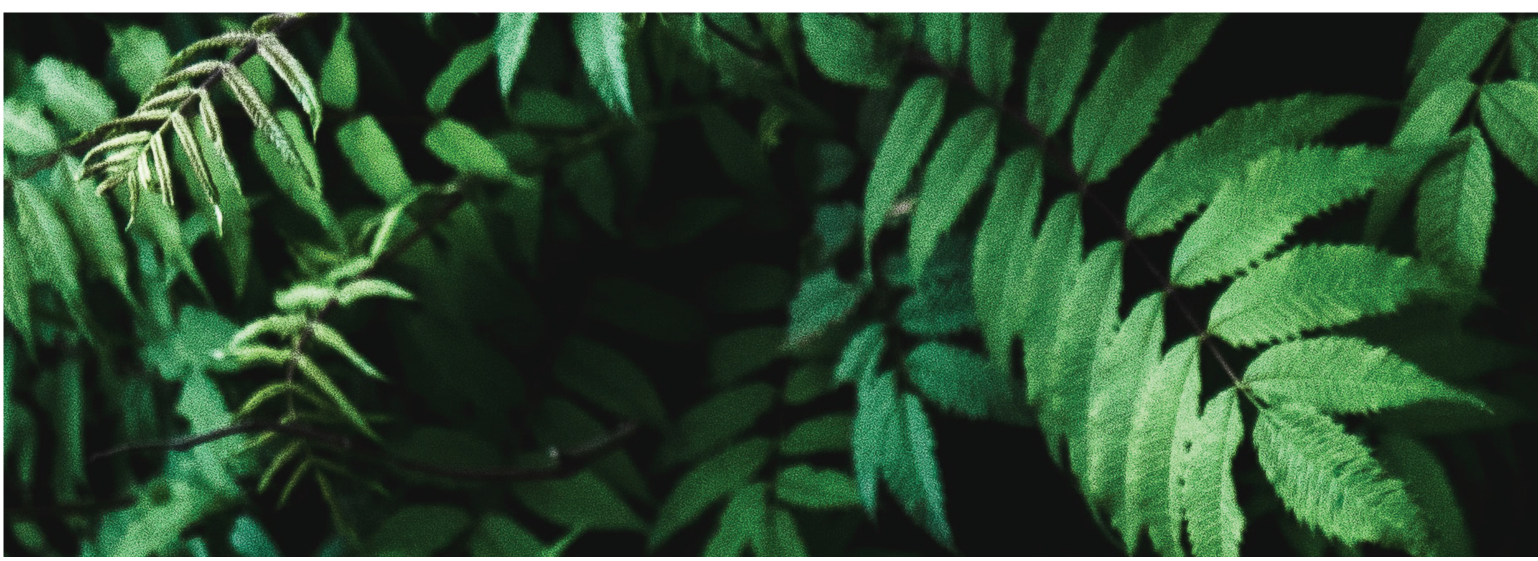
photo : Vashishtha Jogi

It is now well recognized that human activities have caused approximately 1.0°C of global warming above pre-industrial levels, and that global warming is likely to reach 1.5°C between 2030 and 2052, if it continues to increase at the current rate (IPCC, 2018).

As our economies and populations have grown, so too has our negative impact on the climate. However, the climate plays an essential role in human welfare, whether directly or indirectly, through elements such as food, health, shelter and a livable environment, among others. Climate change is, therefore, not only an environmental problem but also a political, economic and social one, posing a range of complex and interconnected policy challenges.

Thus, climate change issues are inherently complex and multi-layered. They impact a range of stakeholders and imply multiple trade-offs across different policy domains and scale levels, particularly across the environmental and economic spheres. For this reason, countries require extensive and rigorous information in order to understand the drivers of climate change, the range of impacts across human and environmental systems and, above all, the appropriate policy response.

However, climate change policy is often pursued in siloes - with different ministries or policymakers working in isolation and using disparate and fragmented sets of information and data which cannot reflect the complexity at hand. This has resulted in policies that do not reflect the trade-offs involved across different policy domains. For example, economic policies often do not consider the full environmental and economic impact of policies because indirect trade-offs and impacts are not fully visible.



The System of Environmental-Economic Accounting (SEEA) is an information framework that can help policymakers break away from siloed policies and understand the trade-offs and complexities involved in climate change policies. As the international statistical standard for natural capital accounting (NCA), the SEEA provides a framework for measuring the environment and its relationship to the economy, providing relevant and pertinent indicators to guide public policy for informing climate change policy. The SEEA covers both individual natural resources (such as energy, forests and water) and ecosystems, as well as their linkages to the economy and human well-being. By uncovering these linkages, the SEEA provides the data needed for policymakers to deal effectively with climate change issues from various perspectives and at multiple scales.

This paper addresses the policy questions associated with climate change, the information requirements to inform policy and the role that the SEEA can play in providing a systematic and coherent information base to support policymaking, policy implementation and policy appraisal.

The paper is structured in four subsequent sections: it addresses the policy problem associated with climate change (part 1); then discusses the potential policy response (part 2); further explores how the SEEA can support information to inform policy (part 3); and, finally, elaborates on the role that the SEEA can play in providing a systematic and coherent set of information to support policymaking, through various indicators and modelling techniques (part 4). The paper also highlights how the SEEA provides a wealth of relevant policy information that can deal with the principal information requirements with respect to climate change policy and, therefore, should be the principal statistical framework to deal in this regard.

photo : Niilo Isotalo

photo : Nico Mksmc

2. THE POLICY CONTEXT

The climate is a complex interactive system involving the atmosphere, land surface, snow and ice, oceans and other bodies of water, as well as the relationship with other living organisms, especially humans.

Climate change is essentially associated with the human activity that alters the carbon cycle, through increased emissions or land use change. These pressures, in turn, are driven principally by direct and/or indirect economic activity (Le Treut, et al., 2007). Understanding climate processes in the context of the interrelationships between the environment and economy can facilitate a complete understanding of the drivers and impacts of climate change and, more significantly, the potential policy response.

2.1 The Policy Issue

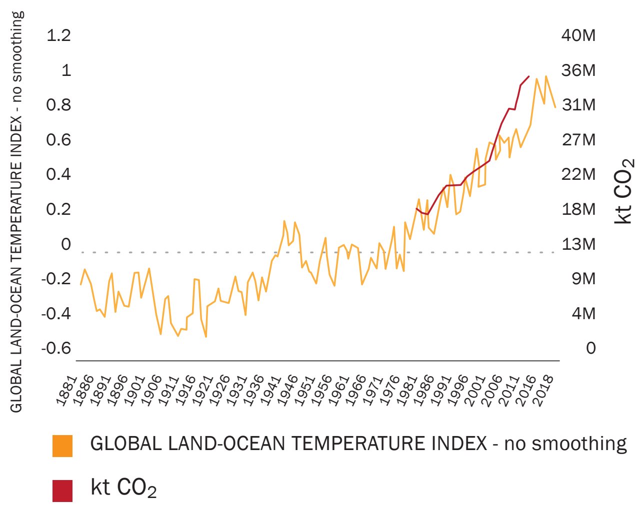
Over the past 50 years, the climate has experienced dramatic changes. These are documented by a multitude of indicators[2], the most important of which is temperature (see Figure 1 below). Today the planet is, on average, 1º Celsius warmer than pre-industrial levels (IPCC, 2018).[3]

Moreover, there is little doubt that this is driven by human activity, which is associated principally, although not exclusively, by an economic model based on energy from fossil-fuel sources (see Figure 2). The projections indicate that, if the current trajectory of emissions continues over the next two decades, the global average temperature of the planet will exceed 2°C with respect to the average temperature observed at the beginning of the 19th century, with the possibility of even going above 4ºC. This could generate an unprecedented impact on the Earth and both human and environmental systems (IPCC, 2014a). Moreover, if the temperature continues to increase at the current rate, global warming is likely to reach 1.5°C between 2030 and 2052 (IPCC, 2018).

2 Changes in the climate are represented with what are referred to as essential climate variables. These are physical, chemical and biological variables or a group of linked variables that critically characterize the Earth’s climate. These are divided into three groups: atmosphere (includes variables on: surface, upper atmosphere, atmospheric composition); land (Includes variables on: hydrosphere, cryosphere, biosphere, anthroposphere); and ocean (includes variables on: physical, biochemical, biological and ecosystems).

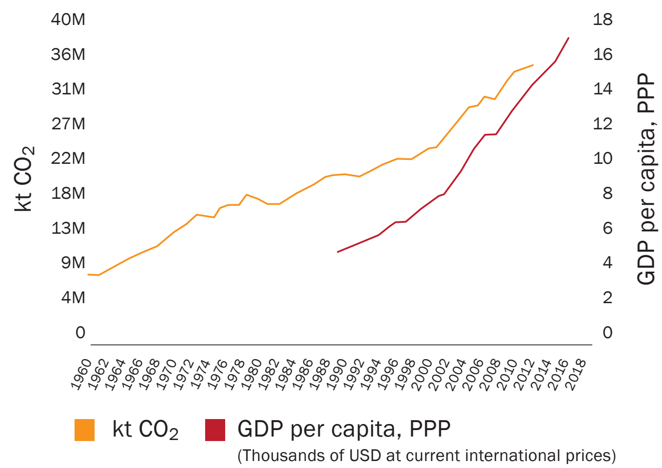
3 Observed global mean surface temperature for the decade 2006–2015 was 0.87°C (likely between 0.75°C and 0.99°C) (IPCC, 2018).

Figure 1: Global temperature and CO_2 emissions



Source: Compiled from information from the Goddard Institute for Space Studies of NASA [GISS] and World Bank

Figure 2: Emissions and GDP per capita



Source: Compiled from World Bank data

2.2 Climate Change Impacts

Climate change generates a significant impact on the environment and, consequently, the economy and human well-being.

Some impacts will gradually affect economic processes, such as those associated with the effects of rising temperatures. However, others may be acute and periodic/sporadic, experienced through shocks that generate environmental or economic consequences, such as flash floods or forest fires (see Box 1 below).

***Box 1:** Principal climate change impacts*

Climate change impacts are associated with the direct effect of increasing temperatures, including feedback impacts of these effects on human and environmental systems such as biodiversity loss. These are some of the most significant impacts:

1. Higher peak and average temperatures in many regions;
2. Increases in frequency, intensity, and/or amount of extreme climate events, generating a loss of human life and social and economic infrastructure;
3. Global mean sea level rise;
4. Impacts on biodiversity and ecosystems, including species loss and extinction;
5. Impacts associated with other biodiversity-related risks, such as forest fires and the spread of invasive species;
6. Global terrestrial ecosystems transformed;
7. Loss of many marine and coastal ecosystems and coral reefs, impacting their growth, development and survival, and thus abundance of a broad range of species;
8. Human health affected by high temperatures and an increase in diseases;
9. Reductions in yields of maize, rice, wheat, and potentially other cereal crops and livestock;
10. Water stress and resource availability.

Source: IPCC (2018)

These impacts are directly affecting the economy as well as our economic infrastructure. However, many of the principal impacts will be indirect. For example, climate change will increase biodiversity loss, which will, in turn, deteriorate multiple ecosystem services, which will result in consequent impacts on the economy and human welfare (IPCC, 2019). While it is possible to recognize that climate change is the result of human-induced activity, it is often difficult to identify precisely which activities are specifically responsible for which drivers and impacts. This is often because governments lack a rigorous information system that connects the environment and economy and is able to trace climate change impacts to their related drivers.

The costs of climate change are expected to be enormous, although there is still some controversy on the exact amount. As of 2018, there were 27 published estimates of the total economic impact of climate change (measured in terms of welfare-equivalent income loss) contained in 22 studies (see Toll, 2018, for a review). Estimates of impacts vary considerably, from positive gains to losses of 6% of gross domestic product (GDP). However, new studies suggest that these estimates might be underestimated, since they do not fully consider the non-linearities associated with climate change impacts, namely the possibility of multiple feedback loops that result in increasingly severe consequences. In a scenario of unmitigated climate change, Burke et al. (2015) estimated that by 2100, the per-capita incomes of 77 per cent of countries around the world would fall relative to current levels. The study further estimates that global incomes could decline 23 per cent by 2100, relative to a world without climate change.

Countries will address the effects of climate change directly by implementing various mitigation and/or adaptation policies. But climate change is so pervasive, and its impacts so ubiquitous, that even those countries that do not respond directly will do so indirectly by implementing actions or policies in response to the effects of climate change, such as natural disasters, forest fires, water scarcity, reductions in agricultural productivity or mass migration. Moreover, although climate change has a global impact, these impacts will be unevenly distributed. It is expected that the most acute consequences will be observed in developing countries due to their greater vulnerability because of geographical exposure, lower income, greater dependence on agriculture and, in general, reduced ability to adapt to new climatic conditions (Stern, 2006).

2.3 Climate Change Drivers

The emissions from human induced greenhouse gases (GHGs), through fossil fuel use and land use change, is the proximate cause of climate change.

Carbon dioxide (CO_2) is the most important GHG, contributing approximately 76 per cent of total emissions, composed of fossil-fuel-related CO_2 emissions that reached approximately 32 Gt CO_2 per year, in 2010 (65 per cent)[4] and CO_2 emissions from forest and other land use changes (11 per cent, see Figure 3) (IPCC 2014a). This originates mainly because of the combustion of fossil fuels and the burning of biomass from specific sectors, such as electricity and heat production, transport and manufacturing

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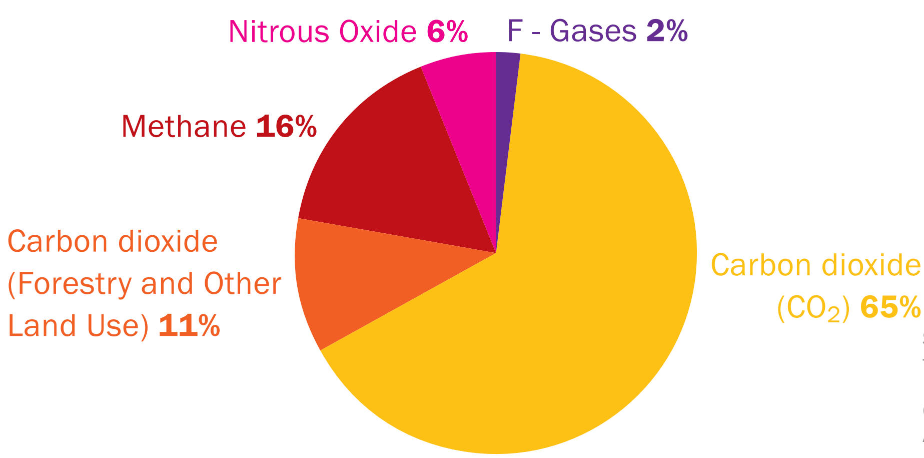
4 However, historically emissions of CO_2 from fossil fuel combustion and industrial processes have been the most significant. They have contributed about 78 per cent of the total GHG emissions increase from 1970 to 2010, with a similar percentage contribution for the increase during the period 2000 to 2010 (IPCC, 2014a).

industries and construction. There are also other GHGs such as methane, nitrous oxide and halocarbons, all of which contribute to climate change.

The emission of all these GHGs, are associated with economic activities that drive the economy and provide goods and services for consumers (see Figure 4 below). Thus, the increase in the production and demand for goods and services, transport and ultimately population growth, generates the indirect and principal drivers that trigger climate change. Therefore, while responses that deal both with limiting and reducing overall GHG emissions are important, it is essential to track other relevant elements, such as consumption, material flows, efficiency and transport systems. This can only be done by modelling the direct and indirect linkages across all sectors.

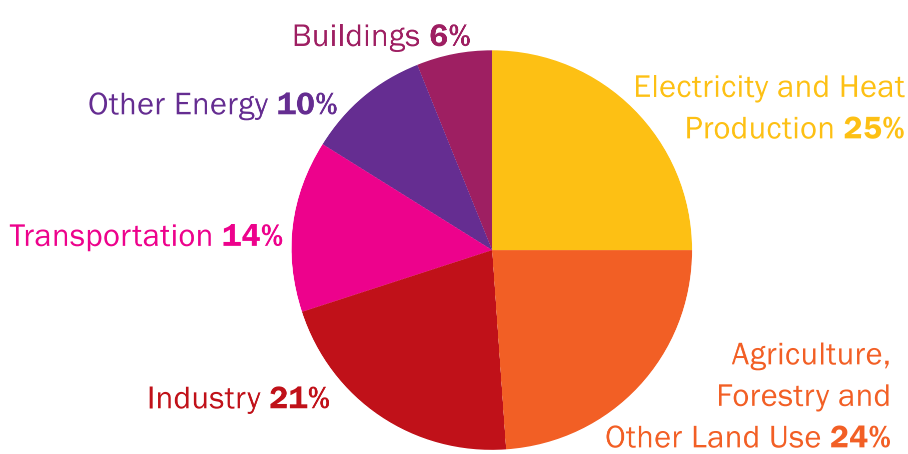
However, even this comprehensive understanding of the drivers of climate change is insufficient. The final drivers of climate change involve a full understanding of climate processes and the carbon cycle. Thus, products that do not apparently generate carbon emissions, such as biofuels, for example, may have significant effects, once the full carbon cycle of the production process has been modelled, considering land use change, transportation, and other inputs that go into the production process (see, for example, Fargione et al., 2008; Searchinger et al., 2008). Similarly, other human activities that cause land use change will significantly impact climate change.

Figure 3: *Carbon emissions by sources*



Source: IPCC (2014); based on global emissions from 2010. Details about the sources included in these estimates can be found in the Constribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Figure 4: *Carbon emissions by sectors*



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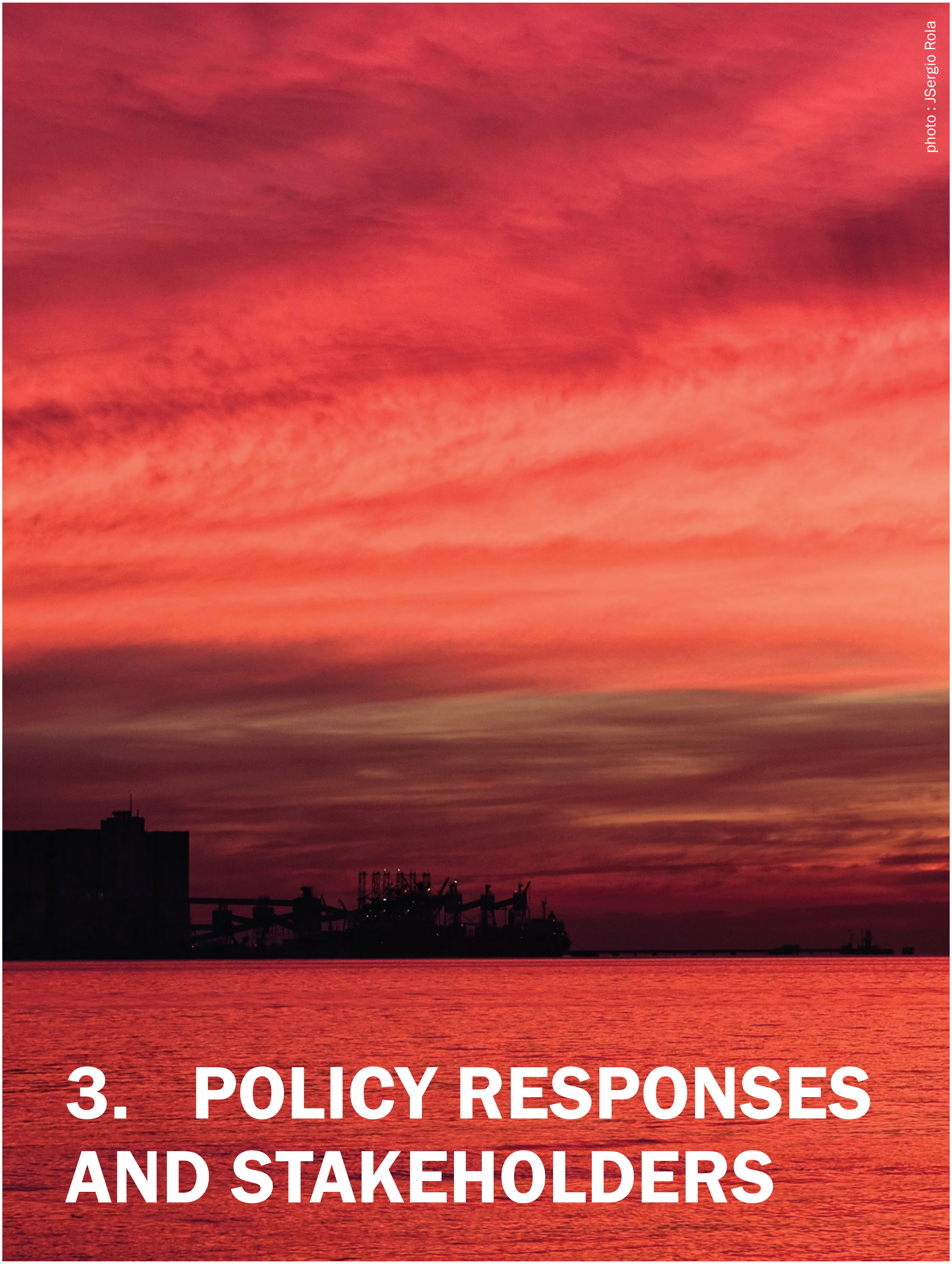

photo : JSergio Rola

3. POLICY RESPONSES AND STAKEHOLDERS

3.1 Policy responses

Broadly, there are three policy responses to climate change. These are:

(i) Mitigation;

(ii) Adaptation and;

(iii) Responses to catastrophic loss or risk[5] (IPCC, 2014b; IPCC, 2014c).

While the first response requires a global approach and may involve complex inter-jurisdictional policy instruments[6], the second and third are essentially local responses (albeit with potentially global impacts). All responses involve considerable costs and may require accounting for international financial flows associated with what is known as "green financing".[7]

In addition, since climate change is a global phenomenon, national policy has direct and indirect impacts on other countries. For example, increasing the cost of carbon intensive activities in one country, through a carbon tax, may not have the intended global mitigation effect. This is because consumers may buy lower cost (but carbon-intensive) imports from other countries which have not implemented carbon taxation. Thus, the level of global carbon emissions may stay the same or even increase, a problem usually referred to as carbon leakage. Alternatively, not adapting appropriately to climate change may have impacts on biodiversity in a specific locality, which could, in turn, create a domino effect and consequently cause impacts on a much wider scale. Therefore, climate change policy responses have multiple interconnected drivers and impacts at different scale levels, which involve different policy domains, suggesting the need for a coherent and comprehensive information system.

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5 This category is associated with the range of policies or actions that deal with catastrophic loss after mayor climate events. These policies are closely associated with adaptation, the distinction is made because typically adaptation policies are ex-ante policy decisions, while these policies refer to ex-post actions associated with unexpected loss, such as the effects of fires, floods, or hurricanes.

6 Such as linked emissions trading systems that regulate the trading of carbon emissions permits across jurisidictions, for example the European Union Emissions Trading System or the Western Climate Initiative that trades permits between California and Quebec.

7 Green financing refers to private of public financial flows for climate or environmental projects.

3.1.1 Mitigation

Mitigation is defined as those human actions that help to reduce or stabilize the concentration of GHGs in the atmosphere to levels that prevent a dangerous anthropogenic disturbance of the climate system (IPCC, 2014b). Climate change is a consequence of the change in the global concentration of carbon in the atmosphere. This means that a tonne of CO_2 emitted anywhere in the world contributes equally to the CO_2 concentrations in the atmosphere. Therefore, global climate mitigation is correctly framed within the context of an international governance structure, which establishes targets or commitments for who must mitigate what and where.

At present, the global governance structure associated with climate change is based on a negotiation process within the United Nations Framework Convention on Climate Change (UNFCCC) that establishes national efforts and commitments for emissions reductions. While emissions targets, or mitigation commitments, are established within the framework of the UNFCCC, countries are free to pursue the mitigation policy they see fit in order to comply with their national commitments. National commitments are now established under the Paris Agreement, which was agreed within the framework of the UNFCCC, through nationally determined contributions (NDCs) (UN, 2015).

Given the role of carbon in the environment, there are essentially two types of policy approaches to mitigate climate change. The first is to reduce or stabilize carbon emissions in economic processes. The second is to strengthen the capacity of the environment to be able to capture and store carbon by protecting carbon intensive ecosystems or implementing efforts to increase carbon storage through forest plantation, among other measures (IPCC, 2014b). These policy approaches are, in turn, pursued through different policy instruments, which are discussed in section 2.2.

3.1.2 Adaptation

Adaptation is the process of adjustment to actual or expected climate change and its effects. It seeks to moderate or avoid harm to humans, such as that caused by catastrophic events from extreme weather events or exploit beneficial opportunities, such as access to new economic resources. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects, for example, by reforestation of native plants or reintroducing a relevant species such as bees (IPCC, 2014c).

Both natural and human systems instinctively adjust or react to climate change. However, the ability to adjust or react is more limited when impacts are considerable and occur at an accelerated rate. Therefore, adaptation as a policy response refers to the explicit human actions, such as investing in produced and natural assets that have the intent to reduce the impact of climate change. Further, it may involve restoring natural systems to enhance or recover ecosystem services associated with climate change processes.

Many of these actions are not usually stand-alone; they are actions or processes in addition to other business-as-usual activities. For example, the new dam built a few feet higher, or a protected area broadened to incorporate changes in precipitation. However, this generates a problem in identifying adaptation activities since they are context specific and often incremental to other intended activities.

3.1.3 Policies on Risk and Catastrophic Loss

Climate change impacts can generate considerable losses from both extreme events (such as hurricanes) to slow onset events (such as the sea level rise). Once they occur, governments must respond, initially dealing with the emergency and, later recovering the environmental and/or physical assets that have been lost or degraded.

Therefore, policymakers are increasingly interested in implementing strategies or developing institutions to deal with these impacts, as well as identifying the costs of responding to climate impact losses and damages after they occur (UNFCCC, 2012).[8] While mitigation and adaptation are essentially ex-ante policy actions, risk and catastrophic loss policies are a type of ex-post adaptation or resilience action that deals with the loss and damage associated with climate impacts.[9]

3.2 Policy Instruments

Policy instruments are tools through which governments implement policy actions. These can be through direct government action e.g. by funding a specific project or programme for example, by providing government services, or by changing individuals or firms' behaviour through, what is known as, an agent-based policy instrument.

There are a variety of agent-based policy instruments, but essentially there are three families of instruments. These are regulatory instruments, market incentives or educational campaigns or, as one scholar has suggested, "sticks, carrots and sermons" (Bemelmans-Videc et al., 1998).[10]

In the case of adaptation and catastrophic loss, instruments can be centred around any of these families of policy instruments. In the case of mitigation policy, instruments are especially complex, since they are associated with the global nature of the mitigation problem, and therefore may involve linked or integrated carbon markets.

Financial flows can be associated with international aid that support the policy responses outlined above. In the specific case of mitigation, financial flows can be associated with carbon market integration. Thus, the financial flow has a counterpart in some form of emissions' reduction. Therefore, policymakers will be interested in the financial flows associated with emission reduction commitments and, eventually, even interested in a global market of emissions reductions or permits, either through the climate change convention process or other bilateral market arrangement.

The implementation of any of these instruments implies costs. These costs can be borne directly by individuals,

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[8] The Warsaw International Mechanism refers to this as loss and damage defined as "the actual and/or potential manifestation of impacts associated with climate change in developing countries that negatively affect human and natural systems" (UNFCCC, 2012).

[9] It should be underscored that there is some controversy here. Climate scientists/meteorologists emphasize that no single weather event can be attributed exclusively to climate, rather that climate change affects risks and vulnerabilities (see for example, UNDP, 2015).

[10] This is a standard typology of policy instruments. There are, however, other typologies of instruments eg. Doern and Phidd (1992) that include public ownership and Hood and Margetts (1983) that proposed a NATO scheme. In addition, Linders and Peters (1989) include contracts and divide taxes from subsidies, and Salamon (2002) includes insurance as well as other subdivisions. The author adopts this one because it is broad and well accepted, refers to 'families' of instruments to encompass other categories, and, above all, is clearly connected to the SEEA environmental activity accounts. See Pal (2004) for a discussion.

firms or the government, but they are all costs that are ultimately borne by society. In turn these actions achieve policy objectives, i.e. mitigation or adaptation which imply benefits to society. A clear assessment of the costs and benefits of policy instruments is essential to evaluate the impact of different policy responses (Boardman, 2006).

Moreover, due to the high costs of both climate mitigation and adaptation, there is interest in exploring which policy instruments achieve the most cost-efficient results. Various modelling techniques, such as computable general equilibrium models, discussed further in this paper, are used for this purpose. Table 1 presents a summary of different policy instruments, their description and examples.

Table 1: *Contributions of SEEA Accounts in Macroeconomic decision contexts*

FAMILY	TYPE	DESCRIPTION	EXAMPLE
Direct Government Action	Government expenditure	Transfers across agencies and institutions, or the private sector	Investment in flood control
	Government services	Current expenditure on services associated with climate objectives or services required in the case of climate extreme events	Current expenditure on protected areas, health, emergency expenditure
Agent-besed policy instruments	Regulatory instruments	Also known as 'command-and-control', these instruments force the economic agent, through regulation and enforcement, to comply with a specified action, such as a certain level of emissions, or practices for adaptation	Mandated emissions control or emissions standards
	Market incentives	Instruments affecting market solutions without imposing regulations. This can be done by imposing an explicit (tax) or implicit (other marked-based instrument) price instrument, such as emissions permits.[11]	Taxes, fees, emission trading systems
	Educational campaigns	Education or information on the consequences of specific practices, aimed at affecting the preferences (and consequent behaviour) of economic agents	Energy efficiency campaigns, public transport campaign

Source: Author

11 If the price is set correctly, a new marginal private cost will fully internalize the social cost of the externality, generating a market incentive to achieve the optimal production and reduce the pollution to the socially acceptable level (Baumol and Oates, 1988).

3.3 Stakeholders

Given the ubiquity of climate change, there is a wide range of stakeholders, including policymakers, who are interested in climate change information. However, not all stakeholders require the same information or level of complexity.

The Conference of European Statisticians (CES) (UNECE, 2017) has established a task force to assess the state of climate-related statistics identifying the climate change policy information needs of policymakers and other stakeholders, as well as their principal information requirements. The categories are presented in Figure 5. The different stakeholder groups not only require different types of data but also different levels of processing and integration across different policy domains. The categories include:

1. The media and the public who require timely, accurate and reliable information that has been highly processed, is easy to understand and has connection across policy domains;

2. Climate policy international organizations who require information reflected in international climate accords and protocols and monitoring mechanisms, but is also connected across policy domains;

3. Decision-makers, civil society and non-governmental organizations (NGOs) who require complex data, but usually in the form of answers to specific policy questions, and often an appraisal of policy impacts and unintended consequences across populations and areas;

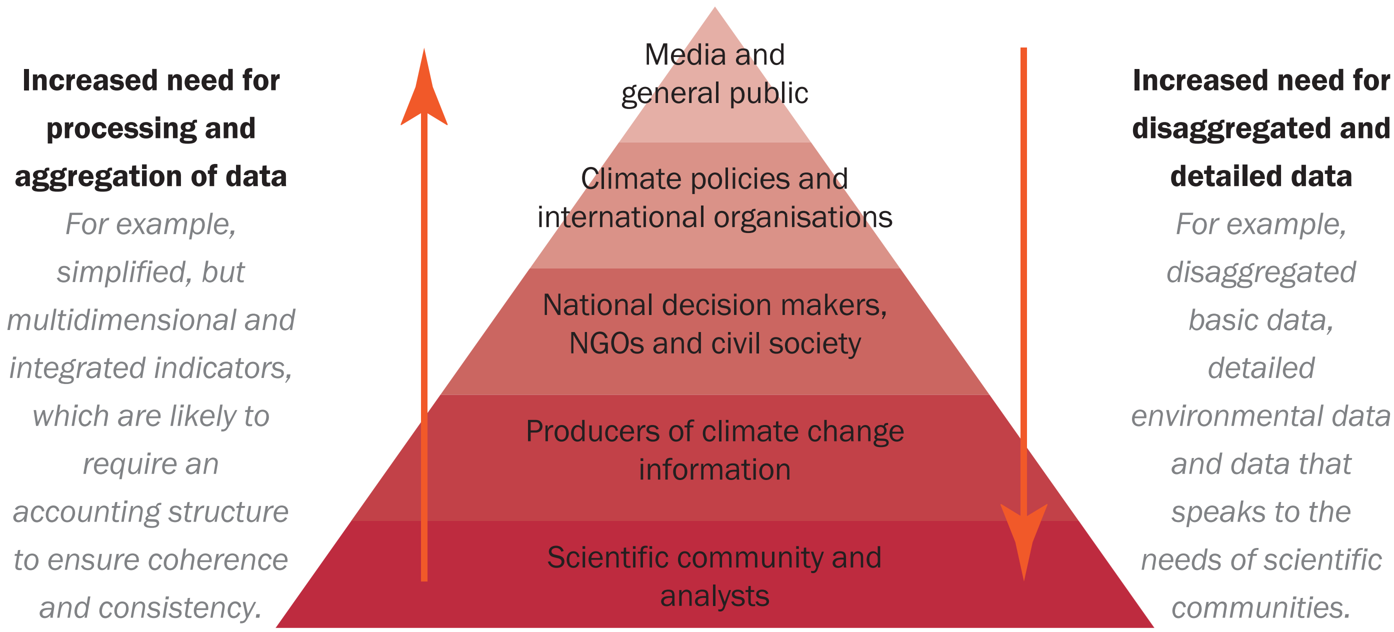
4. Producers of climate information who require more complex environmental data, and may need to connect this information with other economic, social and environmental data; and

5. The scientific community and analysts who require detailed, comprehensive and specialized data.

Thus, user categories can roughly be divided into three groups: the general public (group 1), climate policy and decision-makers (groups 2 and 3), and researchers and producers of information (groups 4 and 5). Moreover, these users could be further grouped into users who: 1) know what they want; 2) need specific data but also guidance in identifying what they need; and 3) have broad, general needs (see Figure 5).

Notwithstanding the different stakeholder needs and levels of data integration and complexity, if decision-makers are to make effective policies, all of these user groups will require data that is integrated across the different policy domains and can support interconnected policies. However, as shown in Figure 5, the exact data requirements of different stakeholder groups will vary in terms of complexity, detail, processing and aggregation. Ideally, a climate change data system should satisfy the requirements of the scientific community and analysts, all the way up to the media and general public. Such a system would require connecting different databases, data systems and policy domains. However, this can be done through a systematic, coherent and integrated accounting structure, such as the SEEA.

__Figure 5:__ Audience for climate change policy information



Source: UNECE, 2017, additional comments from author

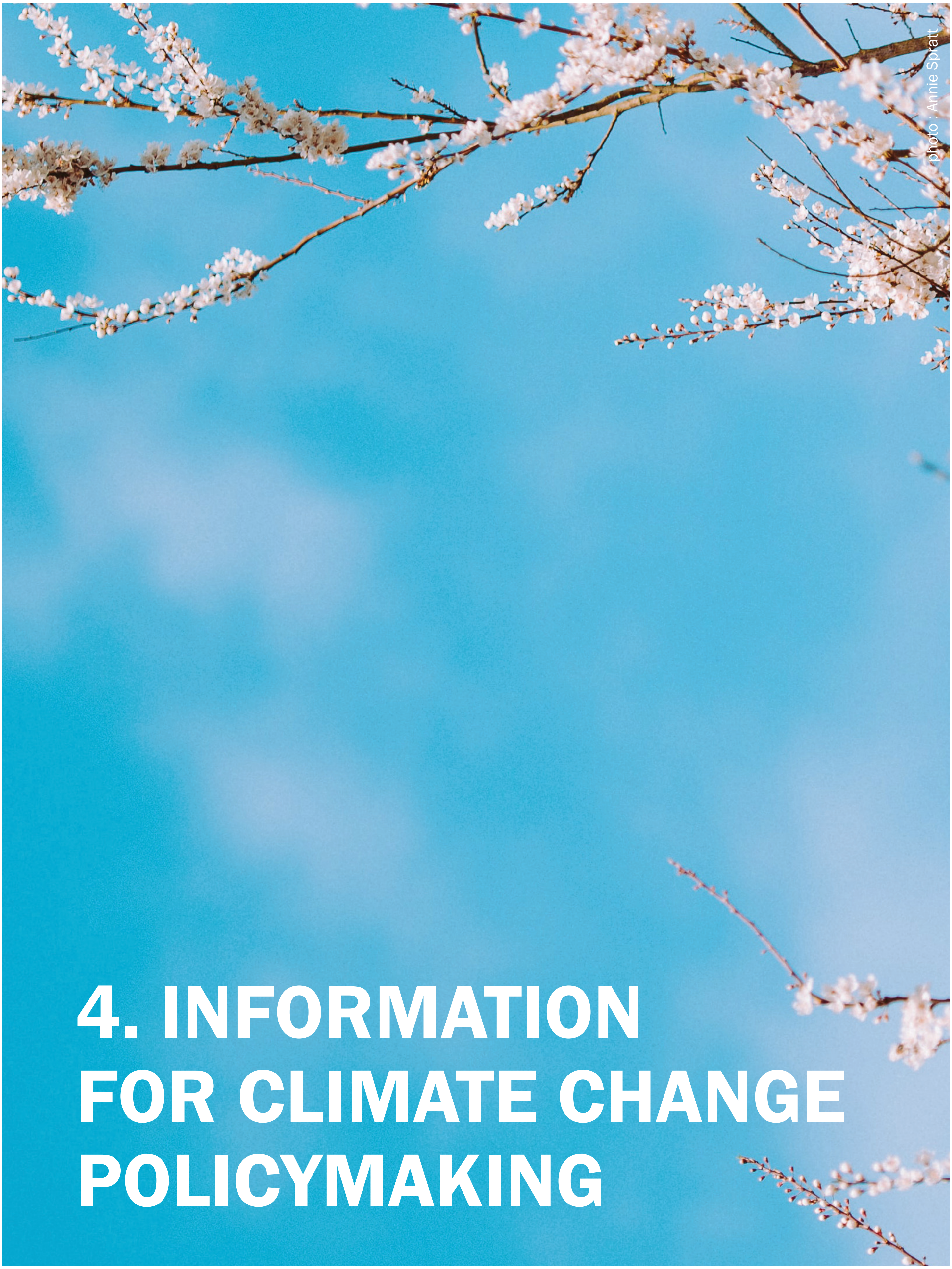


photo : Annie Spratt

4. INFORMATION FOR CLIMATE CHANGE POLICYMAKING

Typically, databases for informing the policy process are not connected, making policy formulation and analysis inefficient and costly (see Hoekstra, 2020, for a discussion).

Policymaking requires a range of information, but especially the capacity to connect and integrate across different policy domains. Policymakers can, however, benefit from consistent, comparable and comprehensive statistics and indicators on the economy-environment interface, by using NCA. The SEEA, by using a rigorous, systems approach, provides the international statistical standard for NCA and a means to provide coherent and consistent data on the economy, human activity and environment. Many countries have developed SEEA accounts - as of early 2020, more than 90 countries around the world have compiled SEEA accounts.[12]

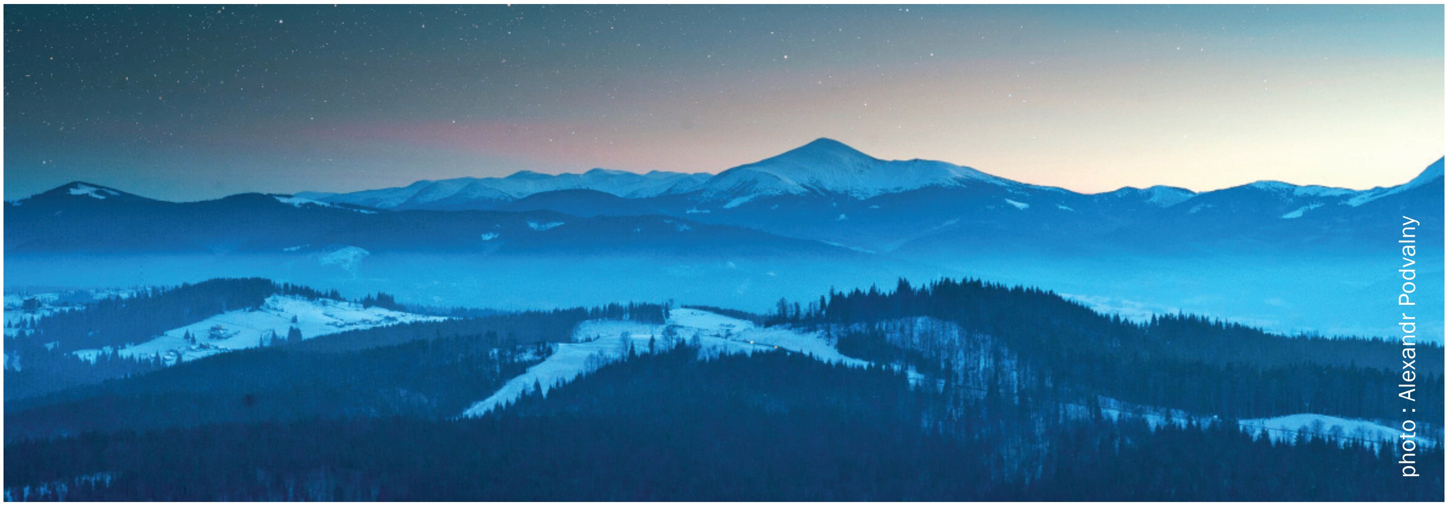
4.1 The SEEA and Climate Change

The SEEA provides a comprehensive approach to the organization of environmental and economic information, covering both stocks and flows, and conceptualizing the interconnected relationship between the environment and economy in a coherent manner.

It therefore connects the different policy domains associated with environmental and economic data, which is precisely the type of information needed to inform the climate change policy process. The link between the environment and economy in the SEEA is made possible because the SEEA uses the same concepts, definitions, classifications and boundaries as the System of National Accounts (SNA), from which GDP is derived.

The SEEA provides two different perspectives of the environment - the perspective of individual natural resources and the perspective of ecosystems. Both are extremely relevant for climate change policy. The first perspective starts from the viewpoint of the economy and accounts for how natural resources (e.g. energy, timber, water, etc.) are used in production and consumption. It also looks at the resulting impact of this extraction and use of natural resources on the

12 As estimated by the United Nations Statistics Division through consultations with countries, international organizations and NGOs. The number of countries compiling the SEEA is officially surveyed through the Global Assessment on Environmental Economic Accounting and Supporting Statistics, which was last administered in 2017 and will administered next in 2020. More information on the Global Assessment can be found here: https://seea.un.org/content/global-assessment-environmental-economic-accounting



environment (e.g. emissions, depletion of natural resource stocks, etc.). This perspective, based on the concept of individual environmental assets, is elaborated in the SEEA Central Framework (SEEA-CF).

The SEEA-CF accounts include both stock and flow accounts. SEEA-CF asset accounts measure stocks of natural resources, allowing users to understand the availability of natural resources and the sustainability of their use. The SEEA-CF also includes flow accounts (e.g. of energy, air emissions, timber etc.), which provide information on which economic sectors are extracting natural resources, using them in production, consuming them and returning emissions (e.g. water emissions, air emissions etc.) back into the environment. Finally, the SEEA-CF also measures economic activities related to the environment (e.g. environmental taxes and subsidies).

The SEEA Experimental Ecosystem Accounting (SEEA-EEA) complements the SEEA-CF by considering how individual environmental assets interact as part of natural processes within a given spatial area, i.e. ecosystems. The SEEA-EEA includes four major types of accounts: 1) ecosystem extent, or the size and occurrence of ecosystems; 2) condition, or the health of ecosystems; 3) ecosystem services, or the contributions of ecosystems to benefits used in economic and other human activity; and 4) assets, or the monetary value of opening and closing stocks of ecosystems.

The SEEA-EEA provides important information for climate change, given that ecosystem services (e.g. climate regulation, flood control, soil retention) play a critical role in minimizing climate change impacts. However, the capacity of an ecosystem to provide these services depends on the extent and condition of that ecosystem. On the one hand, different ecosystems provide different services associated with climate regulation, flood control and soil retention, and on the other, climate change impacts will be reflected in the deterioration of both the extent and condition of the ecosystems, and consequently the services that they can provide to humans. These interconnections can be measured in a systematic way through the SEEA-EEA. In addition, a notable aspect of the SEEA-EEA is that it is spatially explicit, allowing the presentation of the accounts through maps. This means, for example, that ecosystem services such as carbon sequestration be mapped over time, allowing users to identify where and when changes are occurring.

Because the SEEA is so comprehensive, covering individual natural resources, economic activity related to the environment, as well as ecosystems and the services they provide, it is able to provide a large extent of data on pressures and drivers, impacts and the effectiveness of policy responses (see Annex 1 for further details on the SEEA framework). The following section addresses how the SEEA can inform different steps of the policy process and provides illustrative examples (for a comprehensive examination of all of the specific accounts of the SNA, SEEA-CF and SEEA-EEA that can be used for climate-change-related policy questions, see Vardon et al., 2019).

4.2 The SEEA and informing the policy process

4.2.1 Drivers of Climate Change

Currently countries use national GHG emission inventories as their main information system to support national and global mitigation policies. Their purpose is to identify the principal drivers of climate change which then enables the design of effective mitigation policies. However, emission inventories are developed with the criteria and categories established by the International Panel on Climate Change (IPCC). The IPCC establishes recommendations for inventories based on technically delineated processes and sources that follow a different boundary, scope and definitions (e.g. of industry sectors) than those defined in the mainstream economic statistics, namely the SNA, from which GDP is derived.

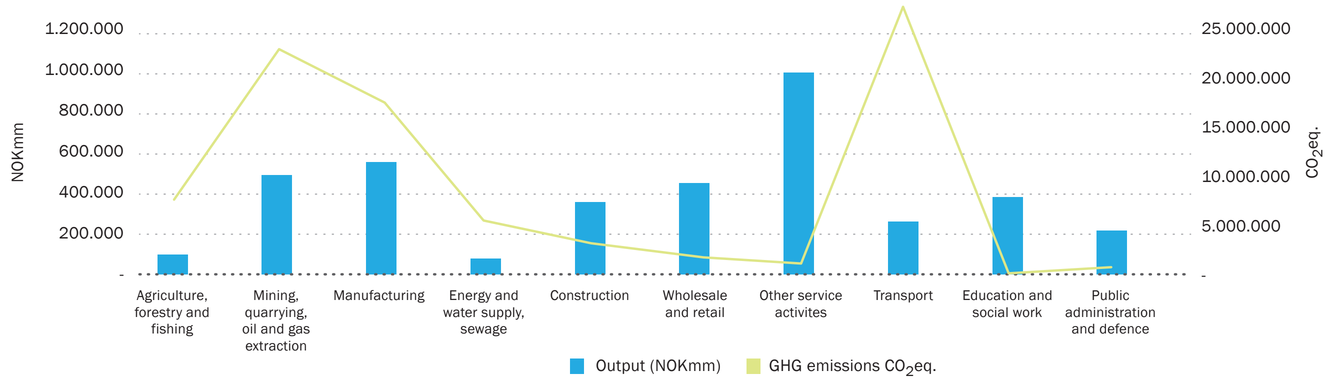
While inventories provide invaluable information for climate change policies, they are limited since the categories for economic drivers are not consistent with other social and economic data that are produced by countries. As a result, these inventories cannot provide a full picture of the potential costs of mitigation and adaptation policies, and, more specifically, the economic and social drivers of climate change. The SEEA accounts, on the other hand, record data using the same concepts, definitions and boundaries as the SNA. Thus, by organizing environmental information using the SEEA, it is possible to immediately connect SEEA data to other policy relevant data systems that provide information on mainstream economic indicators, such as production, value added, GDP and employment (see Annex 2 for detailed table of potential indicators). The example from Norway in Box 2 below illustrates how the link between the SEEA and SNA can provide climate change policy-relevant information for decision-makers through SEEA air emission accounts.

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.[13]

[13] One of the differences between the inventories and the accounts is that the inventories follow the territory principle and measure all emissions taking place on a specific territory (usually a country). On the other hand, the SNA and SEEA include all activity undertaken by residents of a specific territory (usually a country). This has important implications for countries which undertake a significant amount of economic activity abroad, which is increasingly common due to globalization. See Annex 3 for more details on the technical differences between the accounts and inventories.

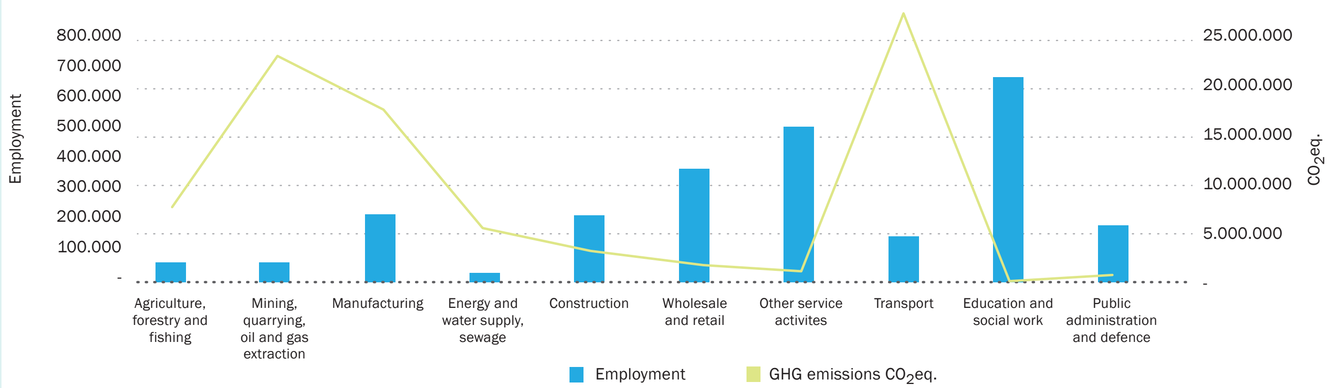
Box 2: *Air emissions in Norway*

NORWAY OUTPUT AND EMISSIONS BY SEEA ACTIVITY



Norway's air emission accounts for 2018 provide information on emissions by economic industry. This information can be easily linked to economic information from the SNA, such as output and employment. This linkage allows users to understand which industries can be targeted to facilitate low-carbon growth.

NORWAY EMPLOYMENT AND EMISSIONS BY SEEA ACTIVITY



As shown in the first graph, while transport, mining and manufacturing contribute significantly to emissions in Norway, their output to the Norwegian economy is relatively limited. In addition, these industries (especially mining) provide limited employment. On the other hand, service activities generate relatively low levels of emissions but contribute greatly to output and employment, suggesting that a shift towards service activities and away from transport, mining and manufacturing could further facilitate low-carbon growth.

Source: Statistics Norway (2019)

At the same time, a country's emissions, stemming from production activities, provide only part of the picture for climate mitigation policy. Since CO_2 emissions have a global impact, policies that reduce emissions at the national level but increase the flow of imports of products with a high carbon content will not have a global mitigation effect. This is especially relevant for those countries, or jurisdictions, committed to carbon neutrality. Achieving carbon neutrality by simply displacing some of their emissions to the rest of the world through their demand for imported products will not have a final mitigation effect. However, information from the consumption point of view, which is often lacking, can be derived from the SEEA (see the example in section 4.1.2).

There is no doubt that emissions caused by production and consumption activities are a key driver of climate change. At the same time, policymakers cannot afford to ignore the implications and impacts of land use and land cover changes on climate change. The SEEA includes land cover and land use accounts, which track patterns in land cover and land use change over time. As land accounts can be constructed in both physical (e.g. hectares) and monetary terms, they can provide information on the economic benefits of land use activities, which can be compared with the associated climate costs involved.

Policy decisions surrounding land cover and land use are highly contested issues, particularly in developing countries where rapid urbanization and agricultural expansion are taking place. Deforestation is a major concern for many developing countries. While forests are a stabilizing force for the climate, particularly by providing valuable carbon sinks, they are also seen as potential agricultural lands, urban areas and sources of income (e.g. timber, fuelwood). In other words, they are both a source and solution for emissions. However, regardless how forests are used, they play an important role in developing countries, involving multiple social, economic and environmental issues. Guatemala provides an interesting example of how the accounts have informed the need for integrated policies for the environment (see Box 3 below).

Box 3: *Illegal logging in Guatemala*

Over the last 60 years, Guatemala has lost approximately half of its forest cover due to agricultural expansion, urban development, and timber and fuelwood harvesting. To better understand the relationship between the Guatemalan economy and its forests, the Government compiled SEEA forestry accounts for 2006.

The accounts revealed the different sectors that were demanding timber products, which grew from an overall 29.6 million m^3 to 34.6 million m^3 in between 2001 and 2010. Further, by developing forest asset accounts, it was made evident that this increased demand was based on illegal logging with a direct impact on forested land. Over 95 per cent of commercial logging operations was conducted outside of legal oversight. Thus, while policymakers may choose to address climate change mitigation through the protection of forests, such policies will be largely ineffective unless additional enforcement and support policies are also introduced.

Source: Banco de Guatemala, 2009; Galvez et al., 2014

While forests are certainly significant for climate change mitigation and adaptation, they are not the only type of ecosystem which plays a stabilizing role in the climate through carbon sequestration. Many types of ecosystems provide carbon sequestration services, whether through vegetation or soil, and these ecosystems play an important role in the carbon cycle and climate. Thus, changes in the extent (i.e. size and occurrence) of these ecosystems, usually driven by economic considerations, can have enormous impacts on climate change, and will be important for informing policy.

The conversion of peatland ecosystems to agricultural land is a telling example of the importance of accounting for the economic drivers of climate change. Peatlands are a type of wetland which provide valuable carbon sequestration services. Although peatlands only cover approximately 3 per cent of the Earth's land surface, they contain between 32 and 46 per cent of the total soil carbon pool, likely exceeding the amount of carbon contained in the world's vegetation (Page and Hooijer, 2016). However, they are also prime land for agriculture and the conversion of peatlands can generate considerable income. However, while draining peatlands creates fertile land for agriculture, it does so at the expense of large CO_2 emissions.[14] Moreover, disturbed peatlands are highly combustible and often lead to fires, which generate even greater emissions.[15] Thus, the conversion of peatlands to agricultural land necessitates serious trade-offs, which are often not taken into account.

However, the SEEA-EEA provides a valuable framework to understand the trade-offs involved in ecosystem conversion. Ecosystem extent accounts can track the changes in the extent of ecosystems over time, in a spatially explicit way (i.e. using maps), allowing policymakers to understand how ecosystems are changing and the economic drivers at play. Ecosystem service accounts can provide valuable information on how these changes in ecosystems are driving changes in ecosystem services, such as carbon sequestration. The example in Box 4 below from Indonesia illustrates the importance of the SEEA-EEA in providing information to policymakers on the extent of peatland conversion and the consequence for climate change.

Box 4: *Competing uses for peatlands in Indonesia*

Indonesia has approximately 45 per cent of the world's tropical peatlands, and it is estimated that they are among the world's largest carbon pools, storing the equivalent of 1.3 to 4 years of global emissions of CO_2 from fossil fuel sources (Page and Hooijer, 2016). However, peatlands are potential real estate for the cultivation of oil palm, one of Indonesia's primary agricultural commodities. Given the increasing scarcity of available agricultural land, peatland is often drained and converted to cropland or plantation forestry areas.

To better understand the magnitude of change and the implications for climate change, the Government of Indonesia compiled ecosystem accounts for peatlands, with support from the World Bank Global Programme on Sustainability. Ecosystem extent accounts illustrated that 52 per cent of peatlands in Kalimantan and Sumatera were converted between 1990 and 2015, often to plantation or agricultural lands. In addition, ecosystem service accounts showed that while these conversions led to an increase in ecosystem services related to the production of oil palm fruit, acacia, rubber and timber, they also led to a large decrease in carbon sequestration services (as shown through carbon accounts).

Indonesia's peatland accounts can play an important role in informing Indonesia's policymakers. Already, Indonesia is starting to prioritize the restoration of degraded peatlands, with the formation of the Peat Restoration Agency in 2016 and specific targets for peatland restoration. The spatially explicit ecosystem extent accounts for peatlands can help pinpoint the specific areas which should be prioritized for rehabilitation. The accounts also have an important role in identifying the physical and monetary impacts of peatland rehabilitation. In addition, the carbon accounts can support the National Action Plan to Reduce GHG Emissions, by monitoring carbon emissions from peatland.

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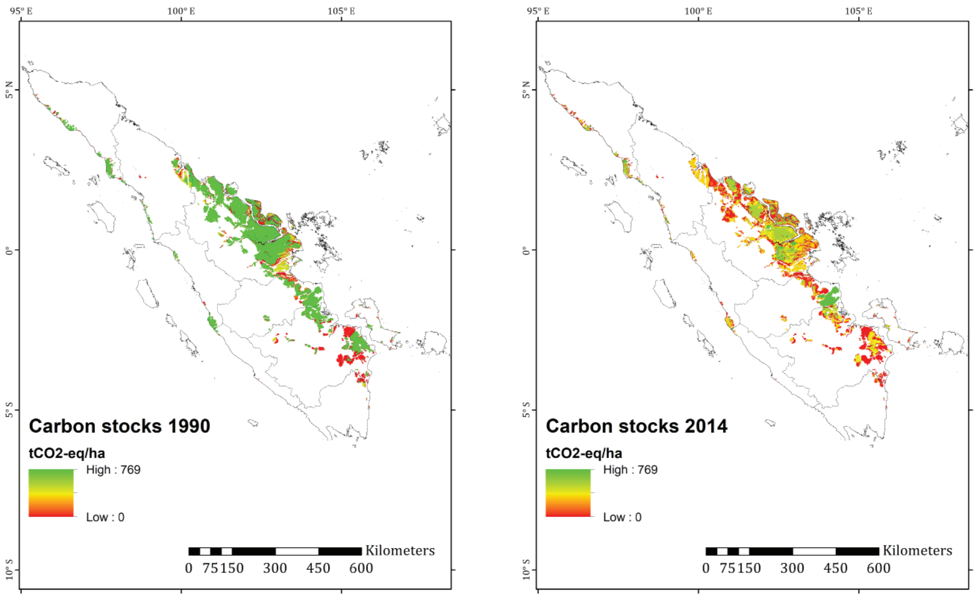
14 When peatlands are drained, carbon stored in the peat is released, resulting in CO_2 via oxidation upon contact with the atmosphere.

15 Peat moisture is the main factor limiting peat ignition - once drained, they become highly combustible atmospheres, often resulting in fires.

SPATIAL DISTRIBUTION OF CARBON STOCKS (VEGETATION) IN SUMATERA PEATLANDS IN 1990 AND 2014



Source: World Bank and BPS (2019)

4.2.2 Impacts

Understanding the range of impacts associated with climate change is central to implementing adequate policy responses. The IPCC provides information on broad environmental impacts, such as temperature increase, water cycle changes, rising sea level, among others. This is important information, but is not fully connected to economic impacts, making it difficult to construct effective policy responses.

For example, climate change is having a significant impact on the water-energy-food nexus.[16] It is projected that changes in the climate will reduce renewable surface water and groundwater resources significantly in most dry subtropical regions. This would impact upon freshwater ecosystems by changing surface and groundwater flows and water quality (Jimenez Cisneros et al., 2014). For example, impacts on rain-fed crops in tropical countries may be one of the most significant impacts of climate change, having important consequences on food security. The impact of climate change on water will also be especially hard on countries with an energy sector based on hydroelectricity.

SEEA-Water accounts can illustrate the impact of diminishing water supplies on all sectors of the economy. In particular, the accounts show the abstraction of water from the environment by specific industries, how water is used in production processes and how water is returned to the environment in the form of water emissions. By providing information on the dependencies of different economic sectors on water and how efficiently different sectors are using water, the accounts can inform policymakers which sectors should be targeted to reduce water usage or increase efficiencies, while minimizing the impact on the economy. As a result, many countries have prioritized compilation of SEEA-Water accounts, as demonstrated in the examples below (see Boxes 5 and 6).

16 https://www.unwater.org/water-facts/water-food-and-energy/

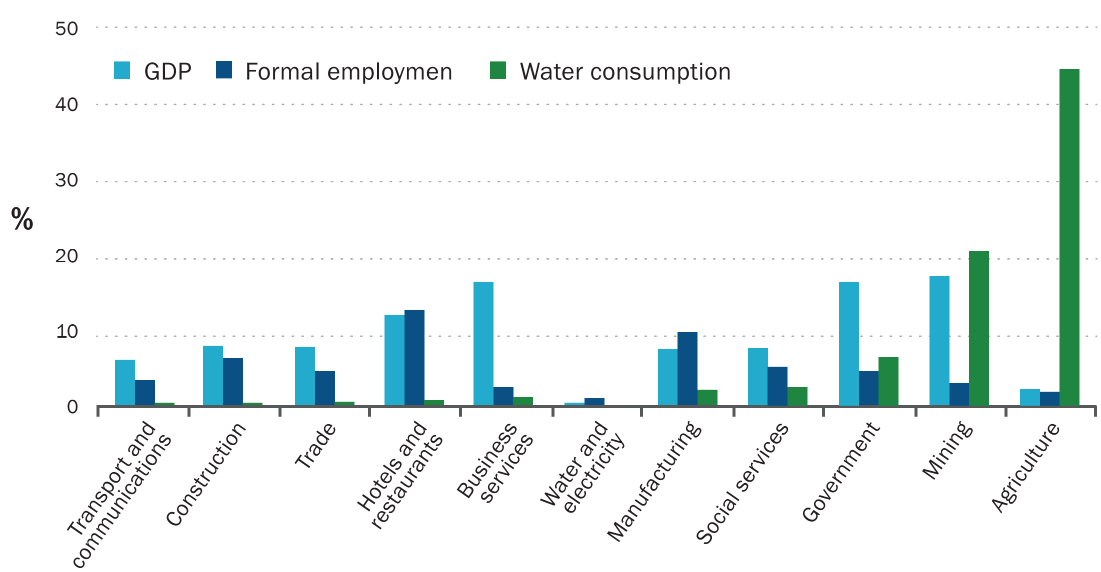
Box 5: *Using the SEEA to responding to water shortages - from Brazil to Botswana*

Countries around the world are suffering from declining and uneven water supply due to climate change. In response, several countries have begun to compile SEEA-Water accounts to better understand where the impacts of climate change will be felt the hardest, and what can be done about it. Two of these countries include Brazil and Botswana.

In Brazil, climate change impacts on water availability are being felt in many cities, with over 850 cities facing water shortages. To inform more effective policies on how to adapt to these impacts, the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatistica or IBGE) and the National Water Agency (ANA) produced their first SEEA-Water accounts in 2018. The accounts highlighted staggering differences in the water-use efficiency of different sectors in Brazil. For instance, water usage per Brazilian real (R$) in the agricultural sector was more than 20 times that of the manufacturing and construction sector, at 91.59 litres/R$ compared to merely 3.73 litres/R$. This indicates that in order to ensure both food security and water availability, policies that are aimed at increasing water use efficiency in the agricultural sector are necessary. At the same time, policies boosting less water-intense sectors, which contribute significantly to the economy (such as the manufacturing and construction sector), could alleviate water stress while maintaining economic growth.

Water accounts have been compiled and used to inform policy in a similar fashion in Botswana. In particular, the mining sector, which forms the backbone of Botswana's economic growth, is highly dependent on water, leaving it extremely vulnerable to climate change. To help understand how effectively different sectors use water resources, the Department of Water Affairs developed water accounts for 2010-2012, with support from the World Bank Global Programme on Sustainability. The accounts show that, given the mining sector's large role in the economy and its high consumption of water, climate change is putting Botswana's economy in danger. While the agricultural sector is also vulnerable and has even lower water-use efficiency rates, it contributes much less to GDP and formal employment. The accounts have helped to inform Botswana's Integrated Water Resource Management and Water Efficiency Plan (IWRM-WE) prepared by the Ministry of Minerals, Energy and Water Resources, ensuring that the mining sector and Botswana's economy are resilient to the impacts of climate change.

SECTOR SHARES IN WATER USE, GDP AND FORMAL EMPLOYMENT 2011/2012



Source: Instituto Brasileiro de Geografia e Estatística (2018); Botswana Department of Water Affairs and Centre for Applied Research (2015).

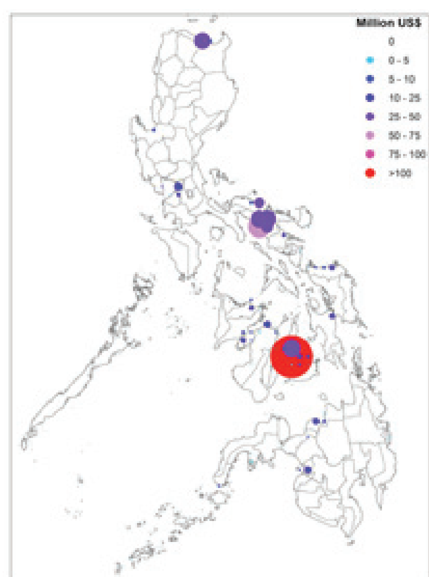
Climate change impacts human livelihoods through the availability of water and other natural resources, but also through the changes it triggers in ecosystems. Many ecosystems play a critical role in reducing climate change impacts, particularly through providing ecosystem services such as global climate regulation, flood control and soil retention. However, these ecosystems and the services they provide are not immune to climate change. Even small changes in average temperature can have a significant effect upon ecosystem functioning and condition. As a result, adaptation policy should be centred on both the protection of natural resources and sustaining the ecosystems that provide valuable ecosystem services. Thus, it is imperative that climate change policies recognize the vital role of ecosystems and the services they provide in minimizing climate change impacts. The links between climate change impacts, ecosystems services and human well-being can be shown through the accounts compiled by the Philippines, as shown below in Box 6.

Box 6: *Accounting for Mangroves in the Philippines*

Ecosystems can provide valuable protection against climate change risks and impacts, such as flooding and natural disasters. For example, mangroves protect coastlines from wind, waves and increased water levels. However, these ecosystem services are often not considered or valued. This lack of recognition has played a large role in the destruction of mangroves in the Philippines. More than 35 per cent of the world's mangroves have been destroyed, usually for agricultural land or human settlement, but the figure is as high as 50 per cent in the Philippines (WWF, 2020).

To better understand the value of the coastal protection services provided by mangroves and to identify where these defenses were providing the greatest protection benefits, the Government of the Philippines developed mangrove ecosystem accounts with the support of the World Bank Global Programme on Sustainability. The accounts were then fed into a scenario analysis of flooding with and without mangroves under different storm conditions. This analysis illustrated that if current mangroves (data from 2010) in the Philippines were lost, 24 per cent more people would be flooded annually, increasing property damage values to over than USD1 billion annually. Moreover, they found that restoring degraded mangroves would have a large benefit in terms of flood protection benefits, in the ballpark of more than USD450 million/year.

The linkage between the SEEA and the SNA means that the value of mangroves can be brought into the national accounts and mainstream economic analysis. By making visible the contribution of mangroves to human well-being, the mangrove accounts in the Philippines have helped provide critical information to decision-makers on how to approach climate change adaptation and disaster risk management.



Map of the spatial variation in flood protection benefits from mangroves in the Philippines. The circles represent the annual expected benefit from mangroves for flood protection (USD millions). The values are the difference in expected damages with current mangrove coverage (2010) and without mangroves.

Source: Wealth Accounting and the Valuation of Ecosystem Services (World Bank Global Programme on Sustainability) (2017)

4.2.3 Policy Responses and Instruments

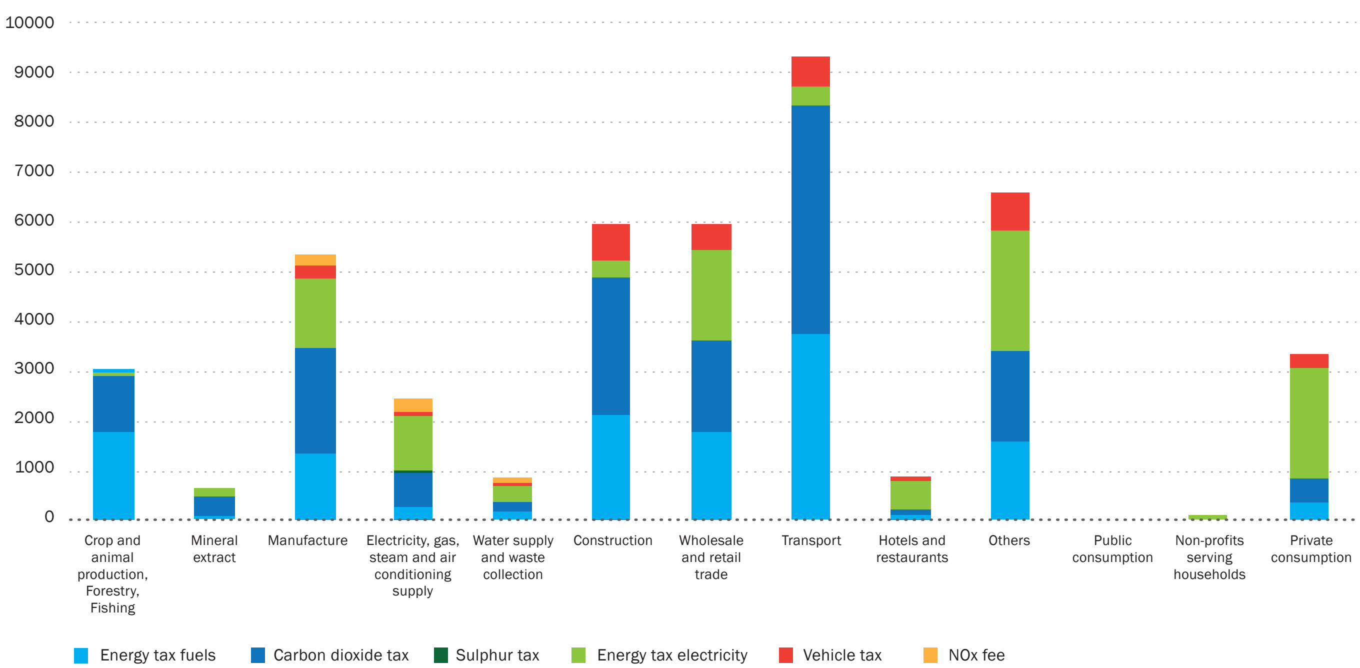
The case studies discussed above highlight how the SEEA can provide an integrated understanding of climate change drivers and impacts, allowing policy makers to identify specific problems and the sectors involved. This information is essential in order to craft effective and cost-efficient climate change policy responses, such as mitigation, adaptation and dealing with catastrophic loss.

In practice, all climate change responses are implemented through policy instruments. That is, by government action through expenditure and/or the implementation of agent-based policy instruments, such as taxes and subsidies. Both expenditures and taxes and subsidies can be identified through information that is currently in the SEEA's environmental activity accounts. These accounts, therefore, provide a means for policy makers to assess the implementation of climate change policy responses. By accounting for the costs and impacts of the policy instruments implemented, it is possible to evaluate the scope and magnitude of climate change policy responses, their effectiveness and efficiency; and thus, reassess or calibrate them.

In the case of climate actions for mitigation, taxes and subsidies are especially relevant because they are considered the principal market instrument used to affect individuals and firms' actions on climate change. The SEEA currently identifies environmental taxes and subsidies, with different levels of disaggregation, including taxes related to climate change. The environmental tax and subsidy accounts can be used by disaggregating those subsidies and taxes that are especially harmful and beneficial for climate change, such as a CO_2 tax, or fossil fuel subsidies.

Information on policy instruments is essential to assess the direct and indirect government response. For example, Sweden has been a leader in the implementation of carbon taxation. Figure 6 presents a SEEA environmental tax account for Sweden. The account identifies different taxes by sector, providing crucial information with respect to the role of taxes in influencing policy outcomes. Linking policy instruments with the drivers and impacts of climate change by sector allows policymakers to fully assess the policy response, its impacts, costs and benefits.

ENVIRONMENTAL TAXES, SEK MILLION BY NACE INDUSTRIAL CLASSIFICATION (2016)



Source: Statistics Sweden, 2015

The Swedish experience is being replicated in other countries that are exploring the use of carbon pricing in general, and carbon taxes in particular, as a policy instrument for mitigation policy. At present, the IPCC categories of emissions drivers, discussed above, are not sufficient to support a coherent analysis of the impact of carbon pricing in an economy, since emissions data is not immediately connected to other relevant social and economic data, such as value added, production and employment.

The SEEA can provide key information to assess the impact of carbon taxes in an economy as well as determine cost effective mitigation policies. For example, between 2001 and 2004, Statistics New Zealand used the SEEA to draw together data from a range of sources to form a comprehensive set of energy and air emission accounts, in both physical and monetary terms. This provided a framework for organizing data used later to analyse the impact of a carbon tax (Webb, 2018).[17]

In addition to accounting for policy responses related to mitigation, the SEEA can also account for policy responses related to adaptation. In particular, the SEEA contains environmental activity accounts, which identify and measure society's response (the public and private sector) to environmental concerns. The scope of these environmental activities encompasses those economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources. Examples of these activities are restoring polluted environments, conservation and natural resource management, and investing in technologies designed to prevent or reduce pollution. While these are not all strictly speaking climate change expenditures, they can inform policymakers with respect to societies response to climate change.

The two basic environmental activity accounts for environmental transactions developed are the environmental protection expenditure account (EPEA) and the environmental goods and services sector account (EGSS). Both the EPEA and the EGSS accounts provide information that supports the understanding of society's response to the challenges of environmental degradation and depletion of natural resources.[18] In particular, there are many climate change expenditures identified in the EPEA, although ideas to better identify climate change expenditures within the SEEA are currently being pursued.[19] For example, the EPEA accounts of Denmark recorded that, in 2016, total environmental expenditures amounted to DKK 32 billion, of which 90% was public sector expenditure, or 1.4% of total expenditure in the public sector. However, this is down from 2.5% in 2013, when environmental expenditures peaked as a consequence of climate change adaptation plans by municipal authorities to safeguard Danish towns against damage caused by flooding in relation to cloudbursts[20]

[17] From the energy accounts, the Treasury prepared two Treasury Working Papers (Creedy and Sleeman, 2004a and 2004b). In these papers, and using data from the SEEA accounts, the Treasury was able to assess what carbon tax rates would do to consumer prices, the changes in household expenditure by type of household, the level of inequality of carbon tax burden and how changes in the structure of the economy affected emissions.

[18] EPEA and EGSS accounts have a very close relationship. EPEA encompasses those economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources. EGSS accounts take a production point of view and have in scope, all products that are produced, designed and manufactured for purposes of environmental protection and resource management.

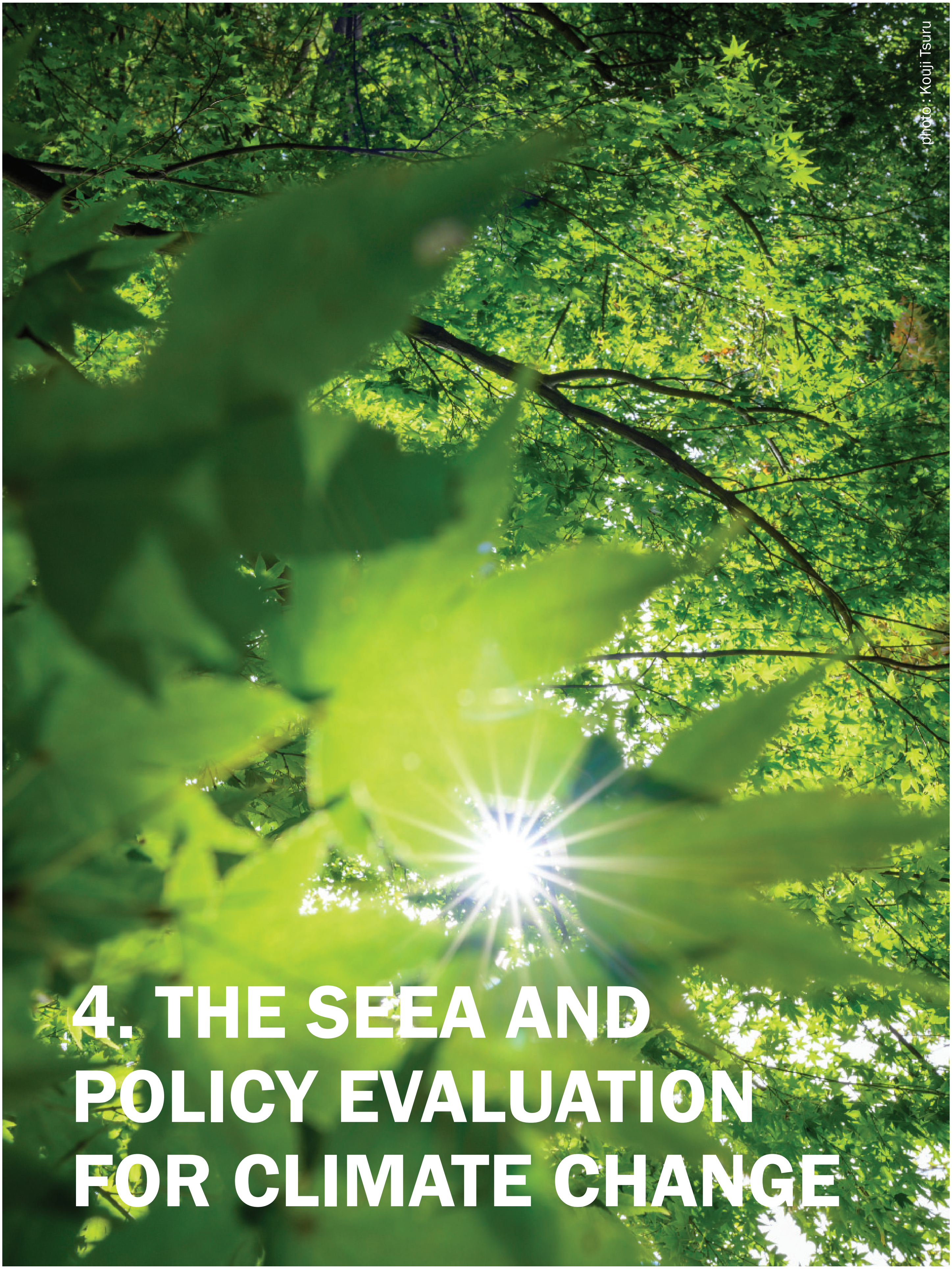
[19] Identifying precisely climate change expenditures presents a challenge. These are transactions that have occurred and are registered in the SNA or the government expenditure accounts and whose purpose is to implement specific climate change actions. Therefore, in order to identify these transactions and, consequently, have a record of the implementation of the policy response, it is necessary to define climate change action expenditures. This is a topic that is currently on the research agenda of the UN Committee of Experts on Environmental-Economic Accounting, a group which provides overall coordination and guidance in the field of environmental-economic accounting.

[20] Sudden and violent rainstorms, capable of causing large amounts of flooding.

(Statistics Denmark, 2018). Fully assessing climate change expenditures and their relationship to other environmental protection expenditures will be essential to understand how society and the government are responding to climate change impacts.

Environmental protection expenditure and EGSS accounts can also provide information on responses to catastrophic events, which are increasing in frequency due to climate change. For example, EPEA accounts include expenditures related to the protection of natural and semi-natural landscapes and cover catastrophic events such as forest fires and floods. Environmental goods and services accounts provide information on the goods and services used in these activities from a production perspective.

Thus, the SEEA provides important information on climate change policy responses—including mitigation, adaptation and responses to catastrophic loss. However, while using accounts to organize information in a systematic way, through different steps in the policy process and across different policy domains, is essential, it is often just the first step. One of the most important aspects of organizing data in a linked accounting structure, such as the SEEA, is that it is able to provide an information base for subsequent analytical and modelling techniques, which are elaborated in the next section.



4. THE SEEA AND POLICY EVALUATION FOR CLIMATE CHANGE

Developing a coherent and consistent statistical framework to fully describe climate change, its drivers and its impacts, is the first stage in evidence-based policy decisions.

The most significant challenge is providing comprehensive evidence for coherent policy analysis. This involves at least two complementary approaches: first, providing relevant policy indicators and, second, developing analytical and modelling techniques to assess the full impacts of climate change and policy responses. This section describes some of the many indicators and analytical modelling techniques made possible through the use of the SEEA[21] which can facilitate an understanding of the different policy choices available to policymakers.

5.1 Indicators and Analytical Techniques

5.1.1 Indicators

A discussion on the full range of indicators that can be developed from the SEEA to support climate change policy is outside the scope of this paper. However, it is important to underscore that the main advantage of the SEEA is the possibility of developing indicators that connect different policy domains in a coherent manner (see UN et al., 2017, for a detailed discussion). This advantage has been recognized in the context of climate change, for example, by the United Nations Economic Commission for Europe's Recommendations on Climate Change-related Statistics, which uses the SEEA as the underlying measurement framework.[22]

The most obvious indicators combine data on air emissions, for example, with standard national accounting aggregates, such as GDP or industry value added. These intensity indicators compare trends in economic activity, including value added, income and consumption, with trends in specific environmental flows such as air emissions, energy and water use and solid waste. These indicators are expressed as either intensity or productivity ratios.[23]

These cross-cutting indicators can be seen in the SDGs, for example in the indicators for Goal 7: Ensure

21 For a more detailed survey of analytical techniques, see Vardon et al. (2019).

22 See: http://www.unece.org/stats/climate.html

23 Where intensity indicators are calculated as the ratio of the environmental flow to the measure of economic activity, and productivity indicators are the inverse of this ratio.

access to affordable, reliable, sustainable and modern energy for all; and Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. In particular, indicator 7.3.1 looks at energy intensity measured in terms of energy and GDP, while indicator 9.4.1 looks at CO_2 emission per unit of value added.[24] Since the SEEA and the SNA use the same definitions and classifications, using the SEEA to derive these indicators results in coherent and consistent data that provides an accurate picture of the economic costs of mitigation or adaptation policy.

In addition, the environmental activity accounts (EGSS and EPEA, in particular) provide information for indicators and aggregates associated with how the economy and governments are responding to environmental degradation and depletion. The most common indicators and aggregates show the importance of environmentally related activities in the economy and characterize those activities through their contribution to the economy, employment and/or trade. The most used indicators are total and relative environmental expenditures in the EPEA or value added and employment generated in the EGSS accounts. These are especially relevant for understanding how society and the economy are directly or indirectly adapting to climate change.

Other relevant indicators are associated with the policy response such as, for example, indicators on financing environmental protection activities, or taxes and subsidies by sector, activity or as they compare with other taxes and expenditures. Annex 2 provides a list of relevant indicators in the case of climate change.

5.1.2. Analytical Techniques

The SEEA supports a range of analytical techniques, especially those focused on the connection between the environment and economic sectors. Two of the most common analytical techniques include decomposition analysis and environmentally extended input-output tables (EE-IOT). Decomposition analysis is a common analytical technique that is especially relevant for analysing environmental impact and pressures. By tracing environmental pressure, such as GHG emissions, and associating them with different economic variables or categories, decomposition analysis makes it possible to determine how the increase (or decrease) of those environmental impacts is associated with specific activities. Decomposition analysis can allow policy analysts to understand, for example, whether increased emissions are due to a greater demand for products, changes in the production structure of the economy, or inefficient production technologies. For an example of how decomposition analysis has helped understand the driving forces of GHG emissions in Denmark, see the related overview paper in this series (Hoekstra, 2020).

24 See: https://unstats.un.org/sdgs/indicators/indicators-list/

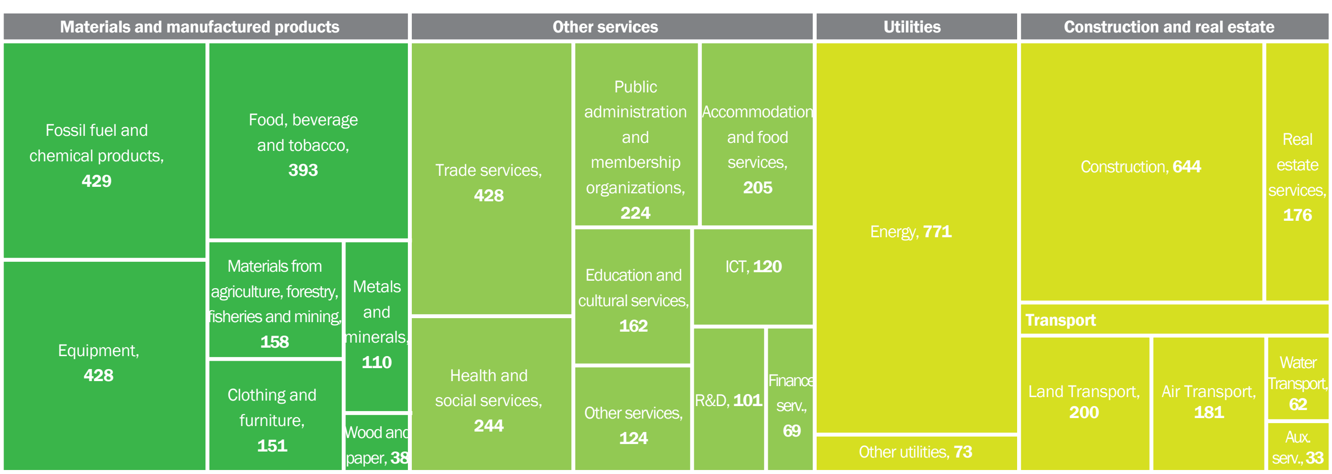
Another common analytical technique is EE-IOT, which is the starting point for a range of sophisticated analytical and modelling techniques on climate change drivers. Environmentally extended input-output tables are integrated data sets that combine information from standard economic input-output tables in monetary units and information on environmental flows, such as flows of natural inputs and residuals that are measured in physical units. The most used environmental flows relate to energy and carbon dioxide. Environmentally extended input-output tables support the calculation of footprints and decomposition analysis, among other analytical techniques (See Annex 1 for further details). For example, EE-IOT have been used to derive carbon footprints which attribute carbon emissions to final demand categories, such as consumption and exports, an important consideration when trying to design policy (see Box 7).

Box 7: *Carbon Footprints in the European Union*

Carbon footprints are one of several analytical applications of the SEEA which make use of EE-IOT. A carbon footprint represents the amount of CO_2 emitted to produce a final product, including emissions from intermediate inputs and emissions embedded in imported intermediate and final products. This important analytical tool can be used to understand which product- and consumption-related policies can help limit emissions and create a path towards carbon neutrality.

To understand how carbon emissions could be attributed to domestic demand in the European Union, Eurostat measured the contributions of broad product groups to the European Union carbon footprint using SEEA air emission accounts for 2017. While most services (apart from transport) generate relatively little CO_2 emissions directly, the European Union carbon footprint revealed the total impact of services - including both indirect and direct emissions. In particular, the CO_2 footprint of the "other services" product group represents 23 per cent of the total carbon footprint of the European Union. This is nearly on par with the carbon footprint from "materials and manufactured products" (24 per cent). Thus, demand for services is clearly a significant driver of CO_2 emissions in the European Union, which has important implications for mitigation policies.

CARBON FOOTPRINTS IN THE EUROPEAN UNION, BY PRODUCT GROUP, 2017



Source: Eurostat (online data code: env_ac_io10)

5.1.3 Modelling

There is considerable experience with modelling exercises on the economic consequences of climate change. These are known as integrated assessment models (IAMs) since they "integrate" a climate science model which identifies emissions and impacts, with an economic model that evaluates effects on output, consumption and other economic variables. There are several well-known models , though it is important to note that all these models depend on essentially three types of information. First, they require projections of climate change drivers and impacts, namely emissions, GHG concentrations and temperature. Second, they require data on economic impacts, such as GDP and abatement costs. Finally, assumptions on social utility and time preferences are also necessary.

Given that there is consensus on the broad drivers and impacts of climate change at the global level, most models tend to have similar results when using similar assumptions. However, when dealing with the local impacts at regional and national levels, the results can vary considerably. Therefore, the systematic and coherent development of climate change information based on the SEEA is essential to ensure accurate policy modelling at the national and regional level.

The SEEA can be used to support computable general equilibrium (CGE) models, which are a class of economic models that combine use of input-output data with the application of microeconomic theory. In the context of the SEEA, CGE models may be developed using information contained in EE-IOT, thus bringing together monetary and physical data (see Annex 2 for more details). CGE models fill an important analytical gap: while EE-IOT models provide a comprehensive means of understanding the current situation or the causes related to historical changes, they are not forward looking. In order to understand the future effects of policies, policy analysts must turn to CGE models.

CGE models have increasingly been used to analyse climate change policies and impacts. According to one review (Babatunde, 2017), since 1996 there have been over 154 studies in peer-reviewed papers centred mainly on policy applications. The growing interest in CGE as a modelling technique suggests that SEEA will be a key information source for climate change policy modellers.

Indeed, policy modellers have already started to use the SEEA in CGE models. For example, the South African Treasury modelled the economic impacts of climate change from the year 2014 to 2050. The model used a CGE model focusing on agriculture and the water sector. The model used a detailed set of water accounts, including river basin models and water demand and supply models. The results showed that while short-term impacts of climate change were limited, by 2050 the impacts, especially associated with the water cycle, were quite significant. The recommendations that emerged were to significantly improve water resource management to deal with the expected climate impacts (World Bank, 2019).

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25 Such as those developed by William Nordhaus (1991, 1993) and Nicholas Stern (2006). Other well-known models include DICE (Dynamic Integrated Climate and Economy), PAGE (Policy Analysis of the Greenhouse Effect) and FUND (Climate Framework for Uncertainty, Negotiation and Distribution) (Nordhaus, 2008, Hope, 2006, and Tol, 2002 a, b).

26 There was considerable controversy with the publication of the Stern review (2006) due the different assumptions on the discount rate and presenting significantly different results from other standard models.

6. CONCLUSIONS

Climate change is an existential threat that poses immense challenges to countries, as well as the international governance system.

Moreover, it generates enormous social, economic and environmental costs and therefore requires the implementation of diverse and innovative policy solutions and approaches. While some progress has been made in recent years with the Paris Agreement and adoption of the 2030 Agenda (among other international agreements), countries must ramp up their mitigation efforts and implement new adaptation and resilience policy responses in order to have any chance of dealing with the impacts observed today and the enormous impacts projected in the future. This require detailed, comprehensive, coherent, and interconnected information on the drivers, impacts and policy responses of climate change.

However, the information currently available associated with climate change affect a number of different policy domains and scale levels. Therefore, information systems are often disjointed and siloed and cannot provide a clear assessment of the trade-offs and policy linkages associated with climate change. A serious and systematic policy response requires the capacity to integrate multiple information systems from multiple sources with different objectives, to provide evidence-based information on the drivers, impacts and policy instruments associated with climate change. Natural capital accounting, through the SEEA, provides an accounting framework that supports a coherent and systematic evidence-based approach to climate change policy.

As of 2020, more than 90 countries have developed SEEA accounts. However, SEEA accounts are not always used systematically for climate change policy. One of the reasons for this is that policymakers are not fully aware of the SEEA and how it can be used to inform climate change policy. Given that there is a critical need for policymakers to develop integrated policies that can effectively address a range of issues associated with climate change policy, the SEEA is an essential tool that can be used as a valuable complement to existing climate information systems, such as emissions inventories.

Nevertheless, there is good reason for optimism. This paper has provided some real-world examples where the SEEA is being used for better, more integrated policymaking and decisions on climate change. In addition, global initiatives such as the SDGs are highlighting the need for integrated data for a variety of policy issues, including climate change. The development of systematic indicators across policy domains as well as cross-domain analytical and modelling techniques will be essential for policymakers looking for ways to answer these global initiatives and effectively respond to the climate crisis.

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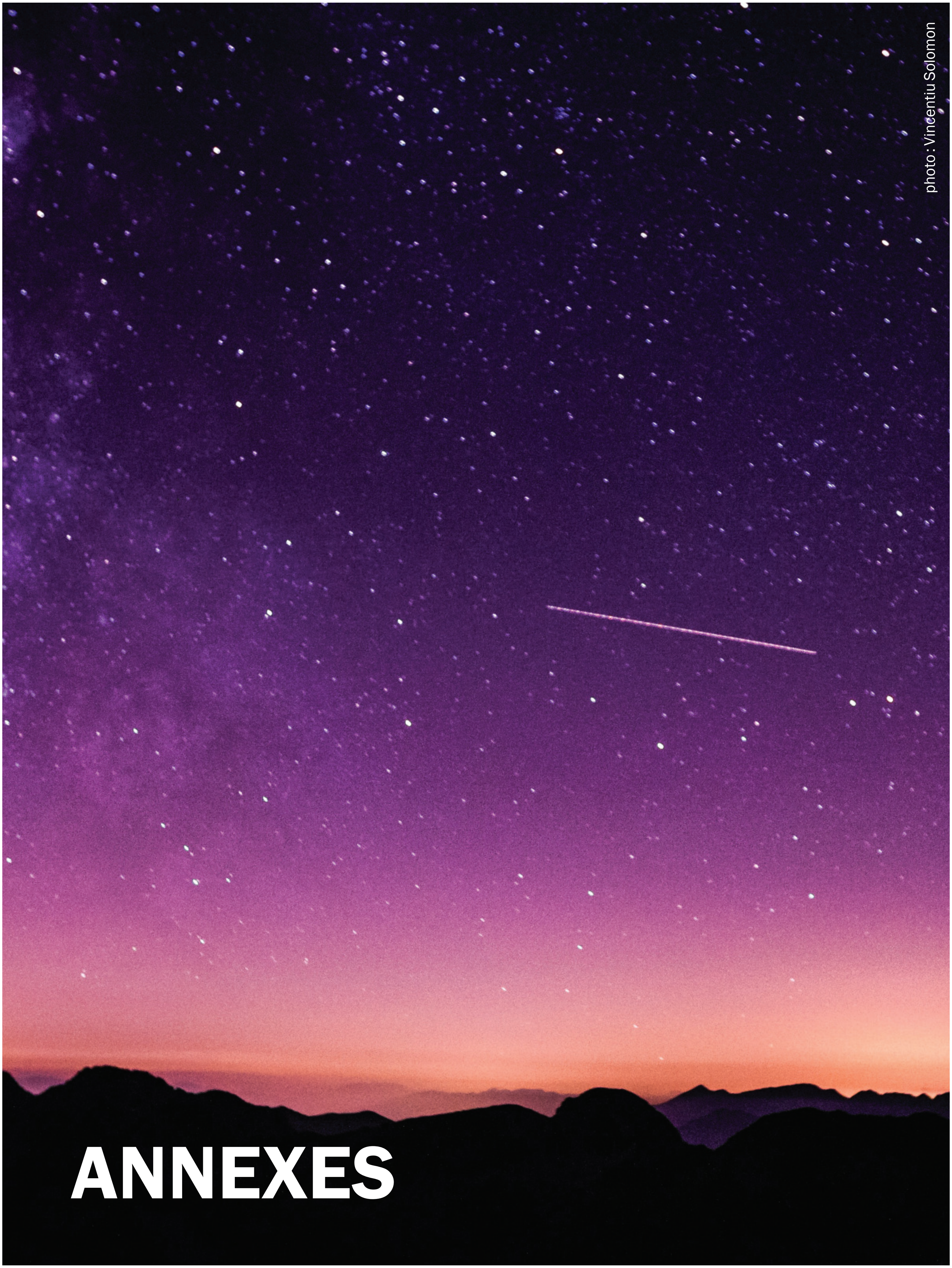


photo : Vincentiu Solomon
ANNEXES

ANNEX 1: 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.

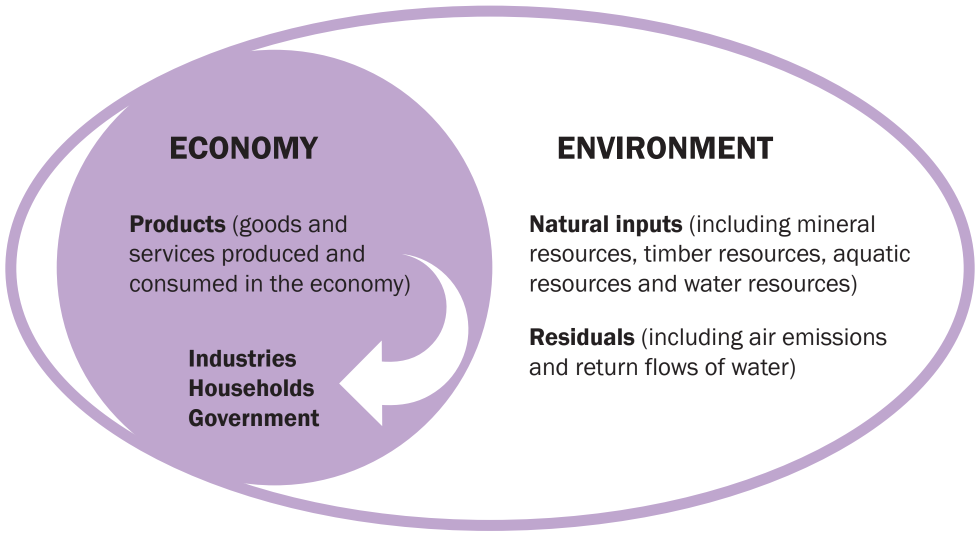
In practice, environmental-economic accounting includes the compilation of physical and monetary supply and use tables, functional accounts (such as environmental protection expenditure, taxes and subsidies accounts) and physical and monetary asset accounts. To assess how the economy supplies and uses natural inputs, SEEA accounts disaggregate flows by different units of production (industries as categorized by the International Standard Industrial Classification[27] 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.

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

__Figure 1.__ Physical flows of natural inputs, products and residuals



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

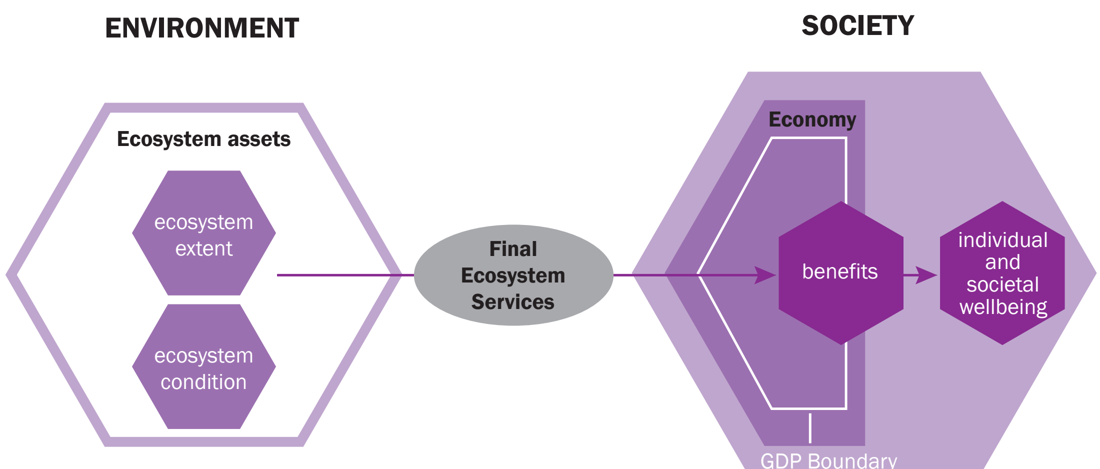
Fundamental to ecosystem accounting is the recognition that ecosystems are the source of goods and services that are essential to economic prosperity and human well-being, now and in the future. In the SEEA, an ecosystem is defined as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (United Nations et al., 2014).[28]

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

[28] 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, 2014). 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.

photo : Ian Chen

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 of the rest of the world	Total
Monetary supply and use: flows						
(currency units)						
Supply of products						
Intermdiate 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, 2014).

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.[29] 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

29 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.

ANNEX 2: EXAMPLE OF ACCOUNTS RELEVANT FOR CLIMATE CHANGE POLICY ISSUES

TYPE OF INFORMATION	ACCOUNTS							
	SNA			SEEA-CF			SEEA-EEA	
	Asset Accounts	Flow Accounts	Functional Accounts	Asset Accounts	Physical Flow Accounts	Environmental Activity Accounts	Asset Accounts	Flow Accounts
Climate Change Drivers		SUT	Government expenditure Account (COFOG)	Land use and Cover Accounts, Forest Accounts, Timber Accounts, Carbon Accounts	PSUT, Material Flow Accounts, Energy Flow Accounts, Agriculture Accounts		Ecosystem Condition by LCEU, Carbon Stock Account	Physical Flow of Ecosystem Services
Emissions				Carbon Accounts	Air Emission Accounts	Environ. Taxes and Transfer		
Sinks				Land use and Cover Accounts, Forest Accounts, Timber Accounts, Carbon Accounts		Environ. Taxes and Transfer	Ecosystem Condition by LCEU, Carbon Stock Account	Physical Flow of Ecosystem Services
Impacts	Physical Assets	SUT	Government expenditure Account (COFOG)	Land use and Cover Accounts, Forest Accounts, Timber Accounts, Aquatic Resource Accounts, Natural Biological Accounts, Water Resource Accounts	Water Accounts, Agriculture, Forest, Fisheries Accounts		Ecosystem Condition by LCEU, Carbon Stock Account	Physical Flow of Ecosystem Services
Mitigation				Land use and Cover Accounts, Forest Accounts, Timber Accounts	PSUT, Material Flow Accounts, Energy Flow Accounts, Agriculture Accounts	EPEA, EGGS, Environ. Taxes and Transfer	Ecosystem Condition by LCEU, Carbon Stock Account	Physical Flow of Ecosystem Services
Adaptation				Land use Accounts, Forest Accounts, Timber Accounts, Soil Accounts	PSUT	EPEA, EGGS, Environ. Taxes and Transfer	Ecosystem Condition by LCEU, Carbon Stock Account	Physical Flow of Ecosystem Services
Recovery and Emergency	Physical Assets			Land use Accounts, Forest Accounts, Timber Accounts, Soil Accounts, Aquatic Resource Accounts, Natural Biological Accounts	Energy Flow Accounts, Agriculture Accounts	EPEA, EGGS, Environ. Taxes and Transfer	Ecosystem Condition by LCEU, Carbon Stock Account	
New Economy	Physical Assets	SUT	Government expenditure Account (COFOG)	Land use and Cover Accounts, Forest Accounts, Timber Accounts, Soil Accounts	PSUT, Material Flow Accounts, Energy Flow Accounts, Agriculture Accounts	EPEA, EGGS, Environ. Taxes and Transfer	Ecosystem Condition by LCEU, Carbon Stock Account	
Climate Expenditure			Government expenditure Account (COFOG)			EPEA, Environ. Taxes and Transfer		
Policy Instruments						EPEA, Environ. Taxes and Transfer		
All the above	All the above	All the above	All the above	All the above	All the above	All the above	All the above	All the above

ANNEX 3: DIFFERENCES BETWEEN IPCC INVENTORY CATEGORIES AND SEEA AIR EMISSIONS

IPCC INVENTORIES	SEEA AIR EMISSIONS ACCOUNTS
Only net emissions are considered, thus emissions from the use of biomass is not considered	Emissions from biomass are considered
Emissions are assigned to the country where the emission takes place	Emissions are assigned to the contry where the company causing the emission is based ('resident')
Emissions are assigned to technical processes (eg. combustion in power plants, solvent use)	Emissions are classified by economic activity (using the NACE classification, as used in the system of national accounts)
Emissions from international shipping and aviation are assigned to the countries where the associated fuel is purchased regardless of where the purchasing company is based	Emissions from international shipping and aviation are assigned to the countries where the airline/shipping company is based, regardless of where the emission takes place

United Nations

System of
Environmental
Economic
Accounting