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NATURAL CAPITAL ACCOUNTING FOR MAINSTREAMING CLIMATE CHANGE IN DECISION-MAKING

Natural Capital Policy Forum, 26–27 November 2018

Background Report

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Contents

Abstract

This paper provides an overview of potential and current uses of the SEEA natural capital accounts for climate-change-related policy uses. This refers to mitigation policies to reduce greenhouse gas emissions and to adaptation policies to make countries less vulnerable against the impacts of climate change. This paper shows that, as climate change touches upon almost all areas of society and government, nearly all natural capital accounts, both from the SEEA Central Framework and the SEEA Ecosystem Accounts, are useful for formulating climate-change-related policies and assessments. Which accounts are most relevant depends on the questions policymakers face.

Many countries have already adopted a set of SEEA accounts that are relevant for informing mitigation polices. Air emissions accounts, for monitoring trends in greenhouse gas emissions, are among the most popular accounts. Many countries also monitor expenditures to climate change mitigation actions using Environmental Protection Expenditures Accounts and Environmental Goods and Services Accounts. Next to that, for formulating policies stimulating renewable energy use or discouraging fossil fuel use or for monitoring structural economic change, also energy accounts and several of the accounts from the System of National Accounts provide relevant information. So far, accounts seem to be used less often for reducing emissions related to LULUCF, the agricultural sector, waste handling or international trade, even though some interesting examples illustrate their applicability with respect to these themes, as well.

To date, only a limited number of countries are using the natural capital accounts for informing adaptation policies. However, those who do use it, such as Australia, Botswana and the Netherlands, show that the information in the natural capital accounts is useful for monitoring a country's resilience to climate change impacts and in preparing adaptation policies. This may relate to adaptation policies aiming at reducing economic damages from flooding or water scarcity with the water, material flow and agricultural accounts. Depending on the adaptation question to be tackled, relevant data may come from the land, water, forest, aquatic, energy (asset) or soil accounts from the SEEA Central Framework or ecosystem services and assets accounts from the SEEA Ecosystem Accounts. The natural capital accounts are being used less for these types of analyses because of insufficiently detailed spatial disaggregation of the accounts or because many of the adaptation questions are raised by subnational authorities who have less access to the natural capital accounts.

The results in this paper show that there is a gap between potential and current use of the natural capital accounts for climate-change-related policies. To advance the application of natural capital accounting to policy, it is important that users, producers and analysists of the accounts unite to decide about the most relevant policy questions and accounts. As almost all natural capital accounts are useful, it is important to choose wisely: those accounts that can be inform the most urgent policy questions. Experiences in the European Union show that, once accounts are being compiled and used for relevant policy issues, a snowball effect may occur, leading to an increased demand for more accounts and policy analyses.

This review also shows that the use of the accounts for climate issues differs between developing and developed economies. Developing economies focus more on natural resources accounts, such as accounts for land, water, forest and agriculture, which are especially used for climate change adaptation issues. The developed economies, on the other hand, focus more on the emission and energy accounts, used for informing mitigation policies. Since the majority of emission reductions needs to come from developed economies, whereas the developing economies more strongly feel the impact of climate change, this makes sense. But nonetheless opportunities for developing and developed countries to learn from each other exist. For developing economies to choose a clean development path it is important to also consider mitigation policies. Likewise, as developed economies equally suffer from the impacts of climate change, it is important for them to also compile accounts that help to define adaptation policies. So, ample opportunities exist for both types of countries to learn from each other on how to use the natural capital accounts.

1 Introduction

This report provides an overview of how Natural Capital Accounting (NCA), following the System of Environmental-Economic Accounting (SEEA), can be used for informing policies relating to both climate change mitigation and adaptation. The report starts from a policy perspective and discusses how using NCA may inform policymakers. It considers which climate-related questions policymakers face and how NCA may help to answer these questions. This may concern policy questions directly related to climate or those about the coherence between climate and other policy fields.[1]

The objective of this report is to provide a starting point for discussions about what government authorities, the private sector and others could do to integrate NCA and natural capital assessments into climate-change-related decisions and policies.

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods' (Art. 1.2 of UNFCCC). According to the latest reports of the Intergovernmental Panel on Climate Change (IPCC, 2018), it is extremely likely that the increase of greenhouse gases in the atmosphere induced by human activity has caused most of the global warming in recent decades. A continued increase of greenhouse gas concentrations in the coming decades will further aggravate climate change, leading to higher average temperatures, more erratic weather patterns, rising sea levels and changing climatic zones. Climate change has 'significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems, on the operation of socio-economic systems or on human health and welfare' (Art. 1.1 of UNFCCC). It will affect all regions of the world, all sectors and all people on earth.

The 2015 Paris Agreement of the UNFCCC forms the heart of climate policies globally. Its main objective is to keep the global temperature rise to below 2°C of above pre-industrial levels and to pursue efforts to limit it to 1.5°C. For this, it has reached agreement on mitigation actions to reduce greenhouse gas emissions, on adaptation actions to strengthen society's abilities to deal with the impacts of climate change and on actions to financially and technically support developing countries to reduce emissions and build resilience to climate change impacts.

The agreement also recognises the importance of 'a robust transparency and accounting system…, reporting information on mitigation, adaptation and support' (Art. 13 of the Paris Agreement). While the UNFCCC has its own standards for reporting greenhouse gas emissions, these can be mapped to the SEEA[2] (UN et al., 2014a; see also Keith, 2018). Many of the indicators needed for the Paris Agreement can be obtained from the SEEA accounts (see Text box 1 and UNECE, 2017). The advantage the SEEA has over other statistical and data systems is that not only do they provide information for monitoring greenhouse gas emissions that are consistent with energy and material inputs in the economy, they can also be used for assessing the impacts of climate change on households, the economy and ecosystems, and for informing sector-specific mitigation and adaptation strategies. The SEEA is being adopted by more and more countries for informing their climate policies.

[1] This report has been presented during the 2018 Natural Capital Policy Forum. The policy forum was held on 26 and 27 of November 2018 in Paris and was organised by the World Bank WAVES Partnership, the UN Statistics Department, the Combining Forces Initiative of the Natural Capital Coalition and the Government Dialogue on Natural Capital.

[2] The SEEA Central Framework (UN et al., 2014a) notes that the main difference is the application of the residence principle rather than the territory principle. For example, a truck driving in Germany but owned by Dutch production company would have emissions recorded against Germany in the UNFCCC, while in the SEEA it would count as Dutch emissions.

This report looks at NCA from a policy perspective, and discusses how such accounts may help policymakers answer climate-related policy questions. Section 2 first discusses the key climate-related policy developments. Section 3 identifies the policy questions pertaining to effective climate-change-policy development. Moreover, it discusses which natural capital accounts can potentially be used in answering these questions. Section 4 discusses a number of mitigation- and adaptation-related examples for which the SEEA has been used, and also shows that the accounts are not yet used to their full potential. In Section 5, conclusions are drawn and gaps between potential and current use are outlined.

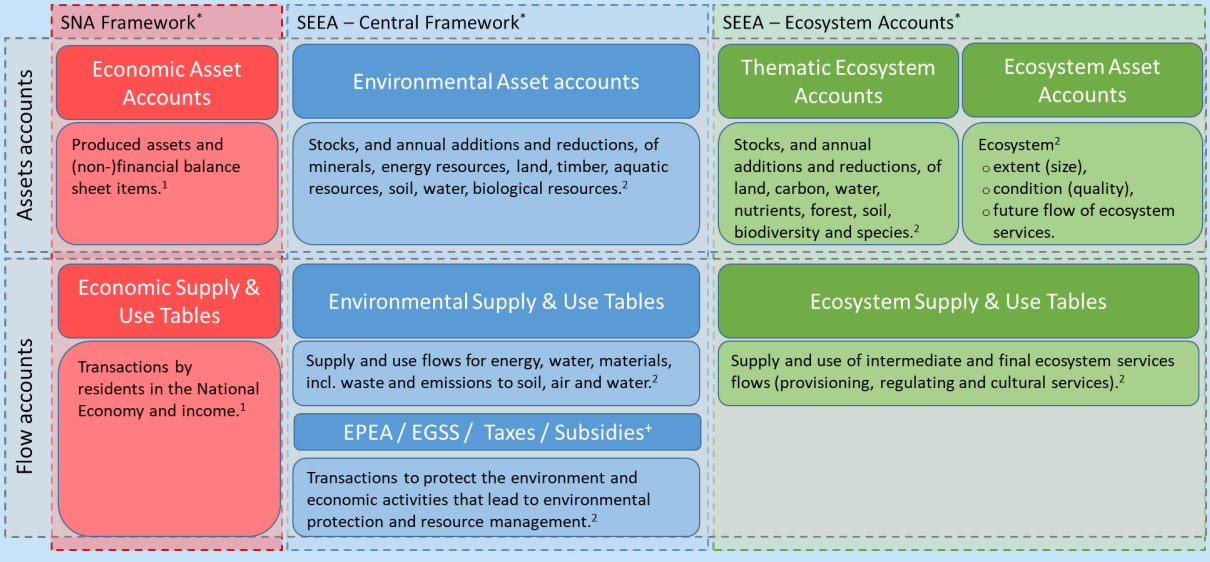
Box 1: Natural capital accounting and the System of Environmental-Economic Accounting

The System of Environmental-Economic Accounting (SEEA) is the internationally agreed standard for natural capital accounting. The SEEA Central Framework (CF) and SEEA Experimental Ecosystem Accounts (EEA) contain the standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics on the environment and on ecosystems and their relationship with the economy (United Nations et al., 2014a,b). They guide the compilation of consistent and comparable statistics and indicators for policymaking, analysis and research.

The SEEA-CF allows for compiling physical and monetary accounts for a range of natural resources, such as minerals, timber, and fisheries, and residuals such as air emissions and waste, and linking these to the System of National Accounts, used for calculation of production and GDP. The SEEA EEA adds to this ecosystem accounts that summarise information about the extent and condition of ecosystems, the status of biodiversity, and their changing capacity to operate as a functional unit and deliver a flow of ecosystem services. Some resources are treated both in the SEEA-CF and the SEEA EEA, such as land, water and agricultural production.

The SEEA distinguishes between supply and use tables, asset accounts and functional accounts (see Figure B1). The supply and use tables record in physical and monetary terms the flows of natural inputs, products, ecosystem services and residuals within the economy and those between the environment and the economy. These include for instance water and energy used in production processes, pollination and soil formation necessary for primary production and waste flows to the environment. Asset accounts in physical and monetary terms measure the natural resources available and changes in the amount available due to extraction, natural growth, discovery and other reasons. They, for example, include mineral, timber, soil, water, land, biodiversity and future flows of ecosystem services. Functional accounts record the transactions between industries, households and governments that concern the management of natural resources and the environment, including green investments, jobs related to conservation or climate action, soil restoration and recycling.

Figure B.1: Schematic representation of the SNA, SEEA-CF and SEEA EEA.



* The three frameworks partially overlap, especially for the environmental and ecosystem goods and services directly used in economic processes such as water, land, materials, energy, timber and agricultural crops. 1) In monetary terms ; 2) In physical or in monetary terms (ecosystem extent and condition accounts only in physical terms); + EPEA = Environmental Protection & Expenditure Accounts ; EGSS = Environmental Goods and Services Sector

All three categories of accounts in Figure B1 include those related to climate-change mitigation or adaptation. Climate-related **assets accounts**, include asset accounts for carbon, land, energy, soil, timber, aquatic, biological and water resources. All of these assets are impacted by climate change and the accounts can be used for monitoring those impacts. They may also be applied to assess whether adaptation measures, such as

those related to water and soil management, improve resilience to climate change. The accounts measuring annual additions to and reductions from the stocks, can also distinguish between normal changes, e.g. of timber or fish stocks due to biological or ecological processes, and more exceptional or catastrophic changes to forest growth, water quality or diseases e.g. due to extreme weather events. Carbon accounting started by accounting of the carbon sequestered in forests and in fossil fuels and related emissions. With the development of the SEEA-EEA, the scope of carbon accounting broadened, encompassing all parts of the carbon cycle and all carbon pools, and thus covering geo carbon, bio carbon, atmospheric carbon, carbon in the oceans and carbon accumulated in the economy.

Climate-change-related **flow accounts** include those for air emissions (greenhouse gases), energy, materials, water, ecosystem services and a variety of resources and products flowing to particular sectors, such as agriculture, forestry and fisheries. Air emissions accounts measure greenhouse gas emissions from the various sources of energy used in the economy, as well as those from deforestation and land-use change. They include both emissions and sequestration related to carbon sinks, such as peatlands or oceans. Information on carbon stocks and flows is used in the SEEA-EEA as an indicator of ecosystem condition and for measuring current and projected flows of ecosystem services, and includes carbon sequestration and net primary production.

Several countries are compiling **environmental activities and economic instrument accounts** in the form of Environmental Protection Expenditure Accounts (EPEA) and Resource Management Expenditure Accounts (ReMEA), following the Classification of Environmental Protection Activities (CEPA) and Resource Management (CReMa) (see Appendix 1 or Statistics Netherlands, 2016). These classifications include expenditures on activities dedicated to climate change, such as protection of air quality, protection and remediation of soil, groundwater and surface water, management of energy resources and of natural forest resources. In addition to these, the Environmental Goods and Service Sector (EGSS) accounts show where economic production takes place, which sectors invest in environmental protection and resource management goods and services, where new green jobs arise, and relating all this to those who consume these goods, those who pay and those who benefit. Finally, this category contains accounts used for monitoring economic instruments, such as carbon taxes, environmental subsidies and transfers, and carbon permits. See also Schenau (2009) and ABS (2012).

2 Climate change and related policies

2.1 Climate change causes and impacts

Increases in concentrations of greenhouse gases in the atmosphere cause climate change. The greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and F-gases (chlorofluorocarbons CFC and hydrofluorocarbons HFC). Their concentrations in the atmosphere increase due to:

- Economic activities using fossil energy, such as coal, oil and natural gas, in transport, heating, electricity generation and industrial processes, that emit CO_2, CH_4 and N_2O;
- Livestock farming that causes CH_4 emissions;
- Deforestation, forest fires and land-use changes that lead to less sequestration and more CO_2 emissions;
- Waste dumping in landfill sites that emit CH_4 and CO_2 emissions for sustained periods of time;
- Agricultural and nature-conservation-related land-use practices affecting above and below ground vegetation, and fertilizer use practices that both cause CO_2, CH_4 and N_2O emissions;
- CFC gases used in industrial processes. However, CFC use has gradually been phased out under the Montreal Protocol.

The impacts of climate change may be severe and will intensify further with increasing greenhouse gas concentrations. The major impacts are higher global average temperatures, leading to greater variability in weather patterns, such as precipitation, evapotranspiration and temperature patterns (e.g. IPCC, 2018; Stern, 2006). This leads to higher probabilities of extreme weather events including heat waves, extreme rainfall, extreme droughts, and more storms and cyclones. This in turn leads to greater risks of flooding, land-use degradation, desertification and biodiversity loss. Moreover, sea levels are expected to rise, endangering coastal areas and low-lying islands. Climate zones are also likely to change, affecting regional crop productivity. IPCC (2018) concluded that global warming of 1.5 ^oC or more above pre-industrial levels increases the risk for 'long-lasting or irreversible changes'. Each additional increase of average global temperature more than proportionally increases these risks. With lower temperature increases, people and ecosystems can more easily adapt and reduce the risk for long-lasting and irreversible changes.

These impacts have large consequences for society. For example, it will have severe consequences on human health, as well as biodiversity, ecosystem assets and ecosystem services on which human well-being depends. If climate change continues unabatedly, then almost all economic sectors will be affected, for example:

- The agricultural sector will suffer from the changing and more erratic weather patterns;
- Fish stocks are expected to decline due to rising temperature of the oceans;
- Industry and energy sectors have to deal with reduced water availability, higher temperatures and changing agricultural productivity;
- The transport, insurance, infrastructure, real estate, and the tourism sectors all have to deal with rising temperatures, more erratic rainfall patterns and higher probabilities of extreme weather events and corresponding damages;
- In heavily impacted coastal areas migration may increase and lead to security concerns.

Countries have to fight climate change on two fronts. On the first front, countries will need to adopt climate mitigation policies to reduce global greenhouse gas emissions and concentrations in the atmosphere in order to limit global warming. On the second front, countries will need to adopt measures and policies adapting to the consequences of climate change. The latter are meant to make countries more resilient and less vulnerable to climate change. IPCC (2018) talks about the

need for 'rapid and far-reaching transitions in land, energy, industry, buildings, transport, and cities'.[3]

2.2 Climate change regulation, measures and policies

At the heart of the global climate policies are the UN Framework Convention on Climate Change (UNFCCC) and its treaties, the Kyoto protocol and its successor, the Paris Agreement. The Paris Agreement did not set emission targets but made countries agree to keeping the increase of the global average temperature to well below 2 °C above pre-industrial levels and to limit the increase to 1.5 °C. Under the Paris Agreement, each country must formulate plans to reduce their greenhouse gas emissions, their Nationally Determined Contributions (NDC). Every five years, countries present new plans that have to be increasingly ambitious in terms of emission reductions. Next to emission reductions, these NDCs also include plans to conserve and enhance sinks of greenhouse gases, such as forests and peatlands.

The Paris Agreement also includes climate adaptation and financing goals. Countries have to enhance their adaptive capacity and reduce vulnerability to climate change. Moreover, they have to avert and minimise loss and damage associated with the adverse effects of climate change. Furthermore, developed countries agreed to support developing countries, financially or through international cooperation, to build a clean, climate-resilient future.

The Paris Agreement affects all corners of policy and society. To include all those who have to contribute, for example, the Netherlands, France and the UK (see e.g. PBL, 2018; Rudinger, 2018) initiated processes whereby all stakeholders (authorities, private sector and civil society) contribute to a transition that not only affects energy production and industry, but also transport, the built environment, land-use and consumer behaviour. When considering adaptation policies, the agreement also affects agriculture, water management, infrastructure development, health care, nature conservation and the financial sector.

At the same time, climate policies relate to many of the Sustainable Development Goals (SDGs). The SDGs, adopted by the UN in 2015, are a set of seventeen development goals for all countries. These include targets for all dimensions of sustainability, and have economic, social, environmental and natural resources targets. 'The SDGs represent a step towards closer integration of policy frameworks and programmes, requiring more integrated information on the interlinkages between the economy, the environment and society' (UN, 2015). Figure 1 shows that SDG 13, on 'Climate Action' is a clear example of such an interlinked target (Campagnolo et al., 2017).

Climate policies are also integrally related to policy developments focusing on wealth, green growth or sustainability in general. Measuring growth, taking climate impacts into account, goes beyond measuring growth of GDP within the System of National Accounts (SNA). Recent initiatives that measure a broader conception of wealth or green growth: include the OECD Green Growth indicators (OECD, 2017a); the Eurostat monitor of sustainable development in the EU (Eurostat, 2017); the World Bank Wealth of Nations report (World Bank, 2018); and the Sustainability Monitor of the Netherlands (Statistics Netherlands, 2017a). These examples track multi-dimensional progress or regress in countries, which is also relevant for tracking the multi-dimensional impacts of climate change.

[3] From the IPCC press release for the 'Summary for policymakers of IPCC Special Report on Global Warming of 1.5ºC approved by governments, 8 October 2018.

Figure 1: Relationship of SDG 13 on 'climate action' with the other SDGs.

Source: Based on Campagnola et al. (2017).

3 Potential contributions of NCA to climate policies

From Section 2, it becomes clear that climate change policies relate to a very broad range of policy fields. In fact, almost all government actions in one way or another relate to climate adaptation or mitigation. Climate mitigation policies broadly focus on greenhouse gas emissions from industry, electricity production, livestock rearing, land-use change and waste management as well as on policies on influencing consumer energy use or consumption patterns. Such policies affect many sectors, including agriculture, fisheries, water management, environmental management, tourism and health care. Integrated policy-making, considering all these dimensions simultaneously, is necessary to bring comprehensive solutions to the climate change problem.

As climate policies cover such a wide range of policies, the multisector coverage and integration with the national accounts makes NCA a perfect starting point to analyse climate change issues and policies. Yet, due to this wide coverage, the question becomes: where to start? Which accounts are useful for which policy questions? To systematically consider how the natural capital accounts can benefit climate change policies, this section discusses which climate-related policy questions are pertinent, how NCA could help in addressing these questions, and which analytical methods would be useful.

3.1 Climate change policies, policy questions and accounts

Climate change policies cover both mitigation and adaptation. Considering the causes of climate change, discussed above, climate mitigation policies can be divided into policies with five types of objectives:

- M1: Reducing emissions from coal, oil and gas usage for energy production, combustion, industrial processes, transport and heating from the different sectors, including negative emissions through carbon capture & storage (CCS) techniques;
- M2: Reducing deforestation, stimulating afforestation, preserving bio-organic matter and reducing emissions from Land Use, Land Use Change and Forestry (LULUCF);
- M3: Reducing emissions from livestock and agricultural practices or enhancing sequestration;
- M4: Improving waste handling to reduce methane and other emissions;
- M5: Reducing emissions from international trade.

Similarly, climate change adaptation policies may be divided into three areas:

- A1: Improving water management, including practices for improving water use efficiency, increasing water storage capacities to safeguard water availability during periods of water scarcity; improving water safety measures with dams, dykes and civil works against sea level rise, river flooding and extreme rainfall events; as well as for preventing water quality problems due to increased risks of salinisation, eutrophication and sewage overflows;
- A2: Enhancing agricultural productivity and nature management, including policies for reducing soil degradation, erosion and sedimentation; enhancing irrigation efficiency; introducing climate proof crop varieties; improving land-use efficiency and resilience; and improving nature and forest management to prepare protected areas for shifting climate zones;
- A3: Preparing cities, infrastructure and society for the effects of climate change, including policies for: storing more water during extreme rainfall events; draining water more efficiently; reducing heat island effects; constructing climate proof buildings; preventing disturbance to critical infrastructure (e.g. water, energy, telecommunication and transport and harbours); and managing disasters and crises.

Designing policies to meet these objectives requires policymakers and policy analysts to raise questions that address the most pertinent problems. Generally, three types of policy questions are raised during various stages of decision-making:

- Q1. What are the status and trends of climate-change-related indicators and of indicators on how society is affected by climate change and climate change policies?
- Q2. What are the possible trade-offs and synergies of climate-change-related policies, in terms of dependencies between policy areas and between impacts on climatic, social, economic and ecological developments?
- Q3. What are the envisaged effects of climate mitigation and adaptation policies on autonomous developments and on the impact of existing policies?

Table 1 gives a non-exhaustive list of potential policy questions raised by either policymakers or policy analysts, for each of the categories of climate change policy. Following the status and trends of mitigation policies (Q1 above for policies M1 to M5) requires measuring: greenhouse gas emissions; changes in fossil fuel and renewable energy use; mitigation expenditures and; how mitigation policies impact on general social, ecological and economic developments in society. For following status and trends of adaptation and adaptation policies (Q1 for policies A1 to A3), measuring the effects of climate change on natural capital (e.g. water, agricultural, fisheries, forestry), produced capital (e.g. infrastructure or fixed capital in housing, construction and machinery) or human capital (esp. health issues) is important.[4]

[4] Schenau (2009) orders the adaptation and mitigation related questions according to the drivers-pressures-state-impact-response framework. The drivers are the economic activities causing greenhouse gas emissions. The pressures are the greenhouse gas emissions. Impacts refer to impacts on natural capital (water, ecosystems, fisheries crop productivity), produced capital (infrastructure, fixed capital in buildings and machinery) and human capital (health). Responses refer to the adaptation and mitigation policies.

Table 1 Policy questions for climate-change-related policies

	Q1: STATUS AND TRENDS	Q2: ASSESS TRADE-OFFS AND SYNERGIES	Q3: EVALUATE POLICIES
MITIGATION			
M1: REDUCE EMISSIONS FROM FOSSIL FUEL USE, INCLUDING CARBON CAPTURE & STORAGE	Trends in greenhouse gas emissions by source and by sector. Trends in mitigation expenditures. Trends in carbon capture technologies and of underground storage	Relationship between economic development and emission reduction. Sectoral shifts and winners/losers of mitigation policies. Relationships between climate and air quality policies. Risks of CCS technologies to society.	Evaluate mitigation policies such as an emission trading system, fiscal greening (taxing emissions), subsidising emission reducing and CCS innovations, setting emission norms for industries and transport.
M2: REDUCE EMISSIONS FROM OR ENHANCE SEQUESTRATION IN LULUCF	Trends in greenhouse gas emissions and sequestration from land use, land-use change and forestry.	Relationship between developments in LULUCF and emissions or sequestration.	Evaluate mitigation policies focusing on land-use management and forestry policies.
M3: REDUCE EMISSIONS FROM LIVESTOCK AND AGRICULTURE	Trends in greenhouse gas emissions from livestock rearing, land use and fertilizer use.	Relationships between livestock and agricultural innovations and emissions.	Evaluate mitigation policies focusing on the agricultural and livestock sectors.
M4: REDUCE EMISSIONS FROM WASTE HANDLING	Trends in greenhouse gas emissions from waste handling.	Relationships between waste management innovations and emissions.	Evaluate mitigation policies focusing on waste handling, land fill and incineration policies.
M5: REDUCE EMISSIONS FROM TRADE	Trends in greenhouse gases included in emissions.	Relationships between trade patterns and greenhouse gases incorporated in imports.	Evaluate impacts of international trade policies on greenhouse gases incorporated in imports.
ADAPTATION			
A1: WATER MANAGEMENT	Trends in water use efficiency per sector, water storage capacities, water safety, water quality, and damages from extreme weather events and corresponding economic effects.	Relationships between changing climate patterns, water management measures and major water and economic indicators.	Evaluate adaptation policies such as water management, water safety. Evaluate efficiency and effectiveness of water safety, water use and water storage measures.
A2: AGRICULTURAL PRODUCTIVITY AND NATURE MANAGEMENT	Trends in agricultural productivity, soil degradation and agricultural innovations. Trends in shifts in ecosystems and protected areas	Relationships between changing climate patterns and agricultural indicators such as production, water use, landslides or degradation, or shifting ecosystems in protected areas.	Evaluate agricultural adaptation and development programmes, such as agroforestry. Evaluate adaptation programmes for protected areas.
A3: PREPARE CITIES AND INFRASTRUCTURE	Trends in adaptation expenditures in cities and for infrastructure.	Synergies and trade-offs between measures to prepare cities and infrastructure for climate change.	Evaluate efficiency and effectiveness of urban and infrastructural adaptation programmes

As climate change affects all corners of society, it is important to learn how climate-related changes lead to trade-offs or synergies, in the various policy fields (Q2 above). This may, for example, relate to learning about: decoupling of emissions and economic developments; relationships between international trade patterns and greenhouse gases incorporated in imports; synergies between greenhouse gas emissions and air quality problems; and trade-offs between reductions of methane emissions from agriculture and developments in the livestock sector. Likewise, for adaptation issues, learning about relationships between climate patterns and water and agricultural indicators, or between the emergence of heat waves and the number of premature deaths, is important.

Policy evaluation questions (Q3) for mitigation may focus on the efficiency of emission trading systems, effects of energy or carbon taxes, impacts of waste management regulations or the effects of clean innovation subsidies. Adaptation-related policy questions may be related to, for example, the impact of new water management measures on flood risk, the effects of irrigation regulations on agricultural productivity, or behavioural effects of subsidies on the number of *green roofs* that are used in the Netherlands for water retention and additional roof insulation.

To answer the above policy questions, policymakers and analysts require information. NCA can provide a large amount of such information (see Text box 1). Especially, the consistency of the accounts across sectors and their linkages with the system of national accounts opens a broad range of applications. In fact, almost every SEEA account provides information for at least one climate-related policy question. However, therein also lies a risk. All accounts may be useful, but when answering a specific policy question, choices have to be made regarding which accounts and indicators to use or which sector, ecosystem or land-use classifications would be most relevant. These choices must be made jointly between policymakers, policy analysts and statistical organisations to avoid accounts being produced that do not cover policymakers' questions.

Table 2 provides a non-exhaustive overview of the SEEA accounts that help answer climate change policy questions (see also Schenau, 2009; UNECE, 2017). The table shows that the key accounts for mitigation policies are the *air emissions accounts* per sector and per type of greenhouse gas in combination with the economic accounts from the System of National Accounts. They can be used for measuring trends in emissions and provide much of the information needed for international reporting obligations under the UNFCCC. *Economic accounts, energy asset and energy flow accounts, material flow accounts* and some of the *ecosystem services stock and flow accounts* are useful for assessing energy- and fossil-fuel-related policies. A time series of these accounts may show: a) whether emissions show lower growth rates or even decline while the economy continues to grow (decoupling); b) changes in emissions, energy efficiency or fuel mix; c) whether energy intensive sectors develop differently from the less energy intensive sectors (structural change); or d) to what extent innovation subsidies or carbon taxes reduce emissions. Mitigation policies focussing on emissions from agriculture, can obtain information from the *agricultural accounts*, the *land accounts* and some of the *ecosystem accounts.* These help to monitor which agricultural subsectors are more energy efficient or which land-use practices are best for carbon sequestration. Similarly, mitigation policies focussing on waste and waste water management need *waste and water emission accounts*. Combined with *material flow accounts*, they can show whether waste production reduces or waste disposal choices change.

For learning about climate change impacts and adaptation policies, other types of accounts are needed. These are, for instance, the *water accounts (e.g. water flow and asset accounts, water quality accounts, disaster-related accounts)*, *agricultural accounts* (e.g. *agricultural supply and use tables* per subsector), *forest accounts (*e.g. *timber stocks and flows* and accounts for *non-timber food products* or *recreation*), *land accounts (e.g. land-cover* and *land-use accounts)*, *ecosystem accounts (*e.g. *biodiversity accounts, soil accounts, ecosystem extent accounts* and *ecosystem services accounts)* and *environmental activity and environmental protection accounts*. Combined with time series information on climate patterns, the accounts can be used for analysing how climate change affects water availability, use and efficiency; damages from droughts or extreme weather events; agricultural productivity; soil degradation; ecosystem changes, etc. Similarly, it can be analysed whether policies or investments result in less vulnerable ecosystem assets and a more sustainable economy. Finally, health accounts, which sit outside of the SEEA, may be of use to assess impacts of climate change on health issues and health expenditures in the economy.

Table 2: Overview of accounts from the System of National Accounts, the SEEA Central Framework and the SEEA Ecosystem Accounts that are useful for climate-change-related policy questions *

CLIMATE CHANGE POLICIES AND NATURAL CAPITAL ACCOUNTING		SNA – National Acc.		SEEA – Central Framework							SEEA – Ecosystem Accounts			
	Account category	Economic Accounts	Satellite Accounts	Environ-mental Activity Accounts	Supply and Use Tables		Asset Accounts Thematic Ecosystem Acc.				Ecosystem Asset Accounts			Eco-system Services Acc.
	Content of Account	Economic Supply & use, Import & export	Labour, education, technology, agriculture, energy, water, tourism	Production & transactions to protect the environment	Supply and use of energy, water, materials	Flows of waste and emissions to soil, air and water	Stocks & resources of minerals, energy, timber, water	Land use and land cover	Stocks of carbon, soils and nutrients	Stocks of biodiversity and species	Extent of ecosystems (size)	Condition of ecosystems (quality)	Future flow of ecosystem services (stock/ resource)	Supply and use of ecosystem services [1)]
	Unit [(a)]	€	€ / Q	€	P / €	P / €	P / €	P	P / €	P	P / €	P	P / €	P / €
Status and trends	(b)													
GHG emission per sector and sub-sector and per source	M													
Agricultural production and productivity	M / A													
Energy use / energy efficiency / share renewable	M													
Material use / resource efficiency	M													
Emissions in traded goods and services	M													
Waste residuals and emissions	M													
Land, forest, soil and marine environmental changes	M / A													
Drought, flooding, water availability	M / A													
Ecosystem services and biodiversity	A													
Climate-related investments, expenditures, taxes and subsidies, government spending	M / A													
Assess trade-offs and synergies														
Relation agricultural productivity & emissions	M													
Relation Energy use – GHG emissions	M													
Relation Material use – GHG emissions	M													
Relation Land use/cover – GHG emissions	M													
Relation Soil use & management – GHG emissions	M / A													
Relation Forest Use – GHG emissions	M / A													

CLIMATE CHANGE POLICIES AND NATURAL CAPITAL ACCOUNTING		SNA – National Acc.		SEEA – Central Framework							SEEA – Ecosystem Accounts			
	Account category	Economic Accounts	Satellite Accounts	Environ-mental Activity Accounts	Supply and Use Tables		Asset Accounts Thematic Ecosystem Acc.				Ecosystem Asset Accounts			Eco-system Services Acc.
	Content of Account	Economic Supply & use, Import & export	Labour, education, technology, agriculture, energy, water, tourism	Production & transactions to protect the environment	Supply and use of energy, water, materials	Flows of waste and emissions to soil, air and water	Stocks & resources of minerals, energy, timber, water	Land use and land cover	Stocks of carbon, soils and nutrients	Stocks of biodiversity and species	Extent of ecosystems (size)	Condition of ecosystems (quality)	Future flow of ecosystem services (stock/ resource)	Supply and use of ecosystem services [1)]
	Unit [(a)]	€	€ / Q	€	P / €	P / €	P / €	P	P / €	P	P / €	P	P / €	P / €
Relation Waste Management – GHG emissions	M		■			■						■		
Relation Water use/availability – climate patterns	A		■		■		■							
Relation Agricultural productivity – climate	A		■	■				■	■				■	■
Relation Ecosystem services/biodiversity – climate	A							■		■	■	■	■	■
Relation Water-related risks – climate patterns	A		■	■	■	■	■	■						
Policy response / implementation / review														
Energy or carbon (CO_2) policies & instruments	M	■	■	■	■	■	■							
Material / resource efficiency policy (Circular Ec.)	M	■	■	■	■	■	■		■					
Nitrogen policy	M / A		■	■		■		■	■	■	■	■	■	■
Sustainable agriculture (mainstream and organic)	M / A		■	■		■		■	■	■	■	■	■	■
Forestry policy	M / A		■	■		■	■	■	■	■	■	■	■	■
Waste and wastewater management policies	M			■		■								
Water management (safety, conservation, supply)	A		■	■	■	■	■	■						
PES for bio-carbon, sequestration or agroforestry	M / A		■				■	■	■		■		■	■
Urban / infrastructure development regulations	A	■	■	■		■								

Notes: * The black cells show which accounts can be applied for answering the respective policy questions. The white cells indicate that the accounts do not provide relevant information for that policy question. The accounts coloured green and blue are covered both in the SEEA-CF and SEEA EEA. (a) P = in physical terms, **€** = in monetary terms, Q = in quantitative terms; (b) M = Mitigation, A = Adaptation.

3.2 Relevant analytical methods

To analyse the research and policy questions identified, policy analysts can choose from a broad set of analytical approaches. The three types of policy questions—about status and trend, synergies and trade-offs, and policy effects—require different approaches. In this, the analysis of policy effects is analytically more demanding than the analysis of status and trends. Table 3 shows which types of analysis are useful.

For analysing status and trends of climate change impacts and policies, numerous indicators can directly be derived from the SEEA accounts. Examples include: greenhouse gas emissions per sector, energy mix, energy efficiency, mitigation expenditures and deforestation. Examples related to adaptation include costs to prevent climate-change-related damages, water availability, agricultural productivity, soil degradation, and health impacts. UNECE (2017) presents a set of key climate change-related statistics and indicators that can be derived from the SEEA (Text box 2).

Text box 2: Framework for NCA-based key climate change statistics for use in policy

In 2017, UNECE, jointly with a group of statistical organisations and international organisations, published a list of key climate change indicators (UNECE, 2017). They started by prioritising policy questions, to assure that the most relevant climate-change-related issues are covered, that the most relevant policy questions are addressed and that upcoming information needs are met. This resulted in indicators that covered:

- the *drivers* of climate change that emit greenhouse gases, such as share of fossil fuels in primary energy supply, support for fossil fuels/GDP, energy intensity of production activities, CO_2 intensity of energy, emission intensity of agricultural commodities, and energy consumption per capita;
- the greenhouse gas emissions that put *pressures* to the climate system, such as greenhouse gas emissions from fuel combustion, land use, production activities or households, and the carbon footprint;
- the *impacts* of climate change on human and natural systems, such as average surface temperature, land area suffering from unusual wet or dry conditions, proportion of degraded land, deaths due to hydro-meteorological disasters, vector-borne diseases, or agricultural loss due to hydro-meteorological disasters;
- the *mitigation policies* to avoid the consequences of climate change, such as share of renewable energy, mitigation expenditures/GDP, share of energy- and transport-related taxes, climate-change-related subsidies, or average carbon price; and
- the *adaptation policies* to adapt to the consequences of climate change, such as government adaptation expenditures as percentage of GPD, changes in water use efficiency, progress towards sustainable forest management, population living in air conditioned dwellings, or area under sustainable agriculture.

For this, the SEEA accounts provide much of the necessary information. This includes physical flow accounts for energy; agriculture, forestry & fishery accounts; physical flow and asset account for water; environmental activity accounts; air emissions accounts; land asset accounts; soil accounts; and ecosystem accounts.

Regression analysis can provide evidence about synergies and trade-offs resulting from climate change or climate-change-related policies. For instance, the accounts provide the data to estimate causal relationships between on the one hand greenhouse gas emissions and on the other hand energy use, material use, land-use changes, ecosystem services supply, water availability or innovation expenditures. These relationships help to show whether a country's economic growth can be decoupled from emissions or whether effective investments are made to reduce greenhouse gas emissions. They also show where adaptation measures are needed to reduce climate change impacts on, for example, water supply, agriculture and biodiversity. The consistency of the accounts—in terms of economic sectors, ecosystem classifications, or spatial boundaries—enables analysts to integrate data for different sectors and areas, which is necessary for these analyses.

Two relevant applications are Structural Decomposition Analysis (SDA) and the Emission Trade Balance. SDA measures to what extent greenhouse gas emissions decouple from economic growth. Using emission, energy or material flows accounts, the extent to which emissions decouple, in relative or even in absolute terms from economic growth can be determined as well as the underlying causes of it. For example, if decoupling occurs, is it due to a change in the size of the economy, the structure of the economy (e.g. a growth of the services sector at the expense of the industrial sector), a change in the fuel mix, dematerialisation of production, or from particular technical emission reduction measures? The Emission Trade Balance allows for determining if and how emissions are related to domestic production, imports or exports.

Table 3: Overview of analytical approaches useful for climate-change-related policy questions

CLIMATE-CHANGE-RELATED POLICIES *		TYPES OF ANALYSIS
STATUS AND TRENDS		
GHG emission and intensity, per sector and source	M	Trends in greenhouse gas emissions and intensity per source and per sector
Agricultural production and productivity	M / A	Trends in crop production, yields, post-harvest losses and crop or yield loss
Energy & Material use / efficiency	M	Trend analysis of energy use/production/efficiency per type of (renewable) energy; trends in circularity of the economy / resource efficiency per sector or type of resource
Emissions incorporated in traded goods and services import or export	M	Trends in imported or exported greenhouse gases that are incorporated in traded goods
Waste recycling rate, residuals and emissions	M	Trends in waste and residuals per sector and in waste management practices including reuse, recycling, etc.
Land, forest and soil changes	M / A	Changes in land/forest area, land/forest/soil use, in soil and ecosystem quality, change in soil organic matter content
Drought, flooding, water availability	M / A	Trends in droughts, excess water, temperature, extreme weather events, flooding; identify locations under threat of flooding or heat islands
Ecosystem services and biodiversity	A	Trends in ecosystem services and biodiversity affecting agricultural productivity, such as pollination, soil fertility, pest control
Climate-related expenditures and health impacts	M / A	Trends in climate adaptation and mitigation-related investments, expenditures and burden, trends in climate-related health expenditures
TRADE-OFFS AND SYNERGIES		
Relation GHG emissions – energy use/material use	M	Regression analysis between GHG emissions per sector and per source and energy use / production / material use to analyse decoupling between emissions and economic growth
Relation GHG emissions – land use/land cover/ soil management / forest use / farming practice	M / A	Regression analysis of GHG emissions / sequestration vs land-use patterns / pressure relationships / agroforestry / forest cover / soil management / agricultural practices / forest management practices
Relation GHG emissions – waste management	M	Regression analysis of GHG emissions / sequestration and waste incinerating / processing / landfilling / waste water processing
Relation climate – water use/availability/risks & agriculture & ecosystem services / biodiversity	A	Regression between temperature/rainfall patterns and water use / availability excess & deficit / risks, crop yields or ecosystem services / biodiversity
POLICY RESPONSES / IMPLEMENTATION / REVIEW		
Energy / carbon / material / resource policies (taxes, subsidies, innovation grants)	M	Econometric analysis to assess potential and historic effects of fiscal policies, trade policies or other measures to change energy use, GHG emissions, material/resource use.
Agricultural/nitrogen policy	M / A	Bio-economic modelling to assess impacts of agricultural, food and nitrogen policies on farming practices, nitrogen emissions and deposition, and resulting impacts on agrobiodiversity, ecosystem and resource conditions, and estimation of the economic costs involved.
Forestry policy	M / A	Bio-economic modelling to assess behavioural impacts of forestry policies on logging patters and resulting impacts on biodiversity, ecosystem conditions, NTFP harvesting and local livelihoods, and estimation of (economic) costs involved.
Waste management policies	M	Modelling behavioural impacts of waste policy on waste generation and waste management.
Water management policies	A	Bio-economic modelling to assess behavioural impacts of water policies on water use and water-related risks. Focus on agricultural and industrial water use and potentials for water-use efficiency.
PES – bio-carbon enhancement / Carbon sequestration / agroforestry	M / A	Econometric analysis to assess potentials and historic effects of PES on organic matter enhancement and carbon sequestration in land and vegetation, in ecosystems, other effects and payment involved.
Urban/ infrastructure development regulations	A	Cost-benefit analysis of public investments in urban spatial planning and infrastructure development

Note: * M = mitigation policies, A = adaptation policies, PES = Payment for Ecosystem Services. The same policies are listed as in Table 2.

Finally, integrated assessment or input-output and general equilibrium models can be applied using information from the accounts. Input-output analyses with environmental extensions support footprint analyses, including carbon footprint indicators showing, for example, greenhouse gases incorporated in a country's consumption basket. For forward-looking policy assessments, several modelling approaches use the natural capital accounts. General equilibrium models are usually directly based on the National Accounts, making NCA perfectly suited to add environmental aspects to the models. This is also true for many other types of environmental-economic models.

4 Experiences with NCA for climate policies

This section briefly outlines current experiences of countries with compiling and using SEEA accounts for climate-change-related policies and developments. Table 4 lists examples of countries using SEEA accounts to identify the causes and impacts of or responses to climate change. Examples are given both for mitigation and adaptation policies.[5] We do not intend to provide a complete overview (which would require a more elaborate search), but illustrate current focus and developments. Table 4 shows that the number of countries working on greenhouse gas emission reduction or carbon accounts for their mitigation policies is substantial and has grown over the last few years. Fewer countries seem to use the accounts for monitoring climate change impacts or for adaptation policies. As many countries have several such accounts in the pipeline, the levels of understanding and use may grow rapidly, in the coming years.

Over 80 countries are currently compiling SEEA accounts (UNCEEA, 2018). About half of them are producing air emissions accounts, which are part of the core accounts to monitor progress regarding the Paris Agreement. Air emissions accounts are compiled in the 28 Member States of the European Union (EU) and the countries associated with Eurostat, such as Iceland, Norway, Switzerland and Turkey. In the EU, air emissions accounts are among a group of six accounts that are mandatory to compile (see Text box 3). Other countries that produce greenhouse gas emissions accounts include Australia, New Zealand, Chile, Colombia, Ecuador, Mexico, Indonesia, Mauritius, Cyprus and the Philippines. The way in which the accounts are set up differs slightly per country, depending on the needs of the individual countries. Experiences in the European Union show that the demand for information from the SEEA accounts is gradually increasing. Where, in the beginning, such accounts were largely supply-driven, parties nowadays increasingly demand information from them (see Text box 3).

Text box 3: From supply- to demand-driven accounts in the European Union

The European Union, through Eurostat, plays a key role in the development, coordination and implementation of accounts in the EU Member States. This development is closely aligned with the related directorates of the EU, with the European Environment Agency (EEA) and organisations such as the OECD and UN-ECE. Recently, the European Commission established a legal basis that requires Member States to compile the following six SEEA accounts: air emissions accounts (AEA), Economy-wide material flow accounts (EW-MFA), Environmental taxes accounts, Physical energy flow accounts (PEFA), Environmental Protection Expenditure Accounts (EPEA) and Environmental Goods and Service Sector (EGSS) accounts, all of which are relevant for climate change adaptation and mitigation policies.

Accounts compilation was first initiated to be supply-driven, with central banks, statistical and environmental organisations constructing the accounts largely in isolation without consultation of the end users. Gradually, this has changed. Authorities at different levels — European, national, provincial or municipal — start to demand information and indicators from the accounts for their policies. The approach followed in the EU shows that, once countries have a first set of SEEA accounts that is regularly published, potential users will, step by step, start using the accounts. In fact, after a while, requests for more detailed and more types of accounts are typically made, ingraining these accounts into the policy process. The initial use most often relates to monitoring purposes, but, later on, the accounts are also being used for policy preparation. In comparison to the macroeconomic data from the national accounts, the SEEA accounts are used by a broader group of users, working more on multidisciplinary topics. This includes economic and environmental assessment organisations and planners, but also environment ministries and water management bodies.

Furthermore, the coherent way in which the SEEA accounts are set up for all EU Member States creates opportunities to use the accounting information for international benchmarking, such as for the SDGs or green growth. The integrated accounts provide much richer information for such analyses than other multi-country sources of information. These comparisons also stimulate countries to keep their key indicators up to date, which in turn leads them to invest more in their national and SEEA accounts.

[5] These examples originate from different sources, including a literature and web search by the authors and a survey conducted amongst a group of countries with whom the UN Statistics Department and the WAVES partnership hold contacts, and from the 2017 Global Assessment of Environmental Economic Accounting (Statistics South Africa, 2017; UNCEEA, 2018). See appendix 2 for a brief summary of the survey results. Increasingly accounting concepts are also used for the private sector. Examples hereof are discussed in Lok et al. (2018). It is noted that it is not too difficult to find out which natural capital accounts have been compiled by countries. Finding out how the accounts are used is less obvious as it is not always properly acknowledged from where data are taken.

The SEEA has specific guidelines for setting up the air emissions accounts. They assign emissions to production activities by all residents of the country. Several other frameworks exist to monitor countries CO_2 and greenhouse gas emissions (Statistics Netherlands, 2013a). Well-known is the IPCC / UNFCCC format for monitoring countries' emissions, generally recording all emissions that occur on a country's territory. Two exceptions are that emissions by road traffic are based on domestic sales of motor fuels, regardless of the user, and it only considers emissions from domestic air transport and shipping. Emissions related to international air transport and shipping are mentioned as a memorandum item. As an alternative framework, only greenhouse gases emitted within a country's territory are recorded; these are closely related to the IPCC format. In a fourth format, one looks at who owns the production activities that cause emissions, either done from within or from outside a country. This is relevant for countries with an open economy and with many multi-national enterprises (Statistics Netherlands, 2013b). In a so-called bridge table, one can show how these frameworks relate to one another (UN et al., 2014a; Statistics Netherlands, 2013b). Finally, an altogether different approach is to assign emissions to final consumption categories. Currently, Sweden is the only country that has set targets for consumption-based emissions (see Text box 4).

Text box 4: Sweden, policy target on carbon footprint

Sweden has adopted a policy target to reduce emissions attributed to the Swedish consumption pattern. In this way, greenhouse gas emissions from Swedish consumption are made part of the country's *environmental quality objectives*. SEEA-based greenhouse gas emissions are used to estimate a consumption footprint indicator of consumption-related 'incorporated' greenhouse gas emissions. This combines domestically generated emissions with emissions incorporated in the goods that are produced in Sweden but consumed abroad. In this way, the country shows its commitment to also reduce emissions outside of its national territory. The footprint analysis is based on an input-output analysis using the input-output tables from the National Accounts and the air emissions accounts (Statistics Sweden, 2015).

Table 4 also shows that several countries are compiling environmental activity accounts for their climate change policies. UNCEEA (2018) shows that Environmental Protection Expenditure Accounts (EPEA) are among the most popular modules of the SEEA. This includes the EPEA compiled by the EU countries for monitoring climate change mitigation expenses based on the CEPA classification (see Appendix 1). An interesting application comes from Sweden, again, where they are used to increase understanding of the environmental impact of the state's budget allocation and of the impact of environmental economic instruments (Statistics Sweden, 2008). Unfortunately, the CEPA classification does not contain separate categories for adaptation expenditures (Statistics Netherlands, 2012). For this reason, it is more difficult to separate adaptation expenditures for the construction of infrastructure such as dykes and dams (or making existing infrastructure climate proof) from recurring maintenance costs of existing infrastructure. At the request of the European Commission, Statistics Sweden (2012) has developed a methodology to disaggregate the costs of adaptation, but to our knowledge this has not been widely adopted yet. Also, the Resource Management Expenditure Accounts (ReMEA) are compiled by several countries, such as Colombia, Mexico, Georgia, Latvia and Lithuania. These are used, for example, for monitoring management of scarce resources, such as forests, water or fisheries, impacted by climate change.

Other environmental activity accounts that are regularly used are the Environmental Goods and Services (EGSS) accounts. The EU Member States use them for monitoring the value added of renewable energy production, of energy efficiency measures or of sustainable technological innovations. Furthermore, several countries, such as Sweden, Australia, New Zealand, Estonia, Latvia, Lithuania, Portugal and Norway, are compiling environmental tax accounts and subsidy accounts. These are used for monitoring the consequences of carbon taxes, natural resource use taxes or innovation subsidies to the state budget, society and the environment, and for monitoring behavioural changes. Closely related, are the CO_2 permit balance sheets that have been set up, for example by Denmark, to keep track of changes in their carbon emission trading system. These balance sheets show the opening and closing stocks of permits as well as their purchases and sales. This information is necessary to monitor how much public money is involved, for example in permit auctions.

Furthermore, Table 4 shows that a substantial number of countries have physical and monetary energy flow accounts, material flow accounts, water flow accounts, ecosystem services and carbon accounts. Especially the carbon, energy and material flow accounts are used for climate mitigation policies. They record for instance changes in energy supply and use, changes of the fuel mix and changes in the shares of renewable energy produced. For instance, in South Africa, energy accounts and air emission accounts are used to calculate carbon intensities and indirectly related emissions; these calculations are subsequently used for formulating the emission reduction strategy. Before introducing a carbon tax, the government wanted to have reliable information about its economic impact, per sector. The South African energy accounts showed that the economic impacts would remain relatively small. These accounts also served as input into an economic model used for establishing the tax level needed to achieve the emissions targets (WAVES Partnership, 2016). Besides using them for climate policies, such accounts are also used, for instance in the European Union, to inform circular economy programmes, or policies focused on dematerialisation and resource efficiency.

For adaptation policies, where resilience of hydrological and ecosystems becomes relevant, water accounts and ecosystem services accounts are being compiled. Countries with vulnerable inland or marine ecosystems, often start compiling accounts for water, forest or aquatic ecosystems. But, currently, only few countries use these accounts to inform their climate change adaptation policies. An exception is the Netherlands, who use them for example for preparing for flood risks (see Text box 5). Furthermore, Botswana uses the water accounts to monitor climate change impacts on particular sectors within the economy and on their water system. Italy uses a water asset account in a model for analysing the expected future climate change impact on water allocation in the Po region. Australia uses its water accounts to assess the impact of water allocation along the main rivers during periods of prolonged drought and the accounts for the Great Barrier Reef to assess the recovery from the 2011 cyclone. Finally, Brazil uses its water (asset) and ecosystem accounts to gain insights into the quality and value of its ecological capital and Green Domestic Product and to learn about its vulnerability to climate change.

Text box 5: Climate adaptation and the SEEA in the Netherlands

In the Netherlands, a substantial amount of information is gathered and knowledge developed about the possible impacts and risks of climate change and the need for adaptation policies. This includes information about impacts of the increased risk of flooding on economic assets, which is obtained from the national and environmental accounts. Recent insights show that, in addition to the water-related adaptation challenges, it is urgent to make critical infrastructure and networks resilient to climate change impacts and to take the impacts of climate change into account in regional and local spatial development (PBL, 2015).

The critical infrastructure and networks that are vulnerable to climate change include the primary dykes and the energy, ICT and transport infrastructure. The Dutch environmental accounts provide indicators that can serve as early warning indicators for climate change impacts. For this, the water, agricultural and material flow accounts are used to estimate, for instance, the yearly level and the current and forecasted future distribution of irrigation water over the country; this indicator informs farmers to anticipate irrigation decisions to future droughts. Other elements of the national 'critical infrastructure' have to undergo a 'stress test' to assess their climate resilience, such as for energy, ICT and transport infrastructure. This test also relies on information from the national accounts and the natural capital accounts. The Netherlands, being a low-lying country, has a dedicated policy to protect the country against flooding, ensure fresh water availability and contribute to a climate-proof and water-robust spatial planning. For this, a so-called 'signalling group', consisting of knowledge institutions, looks after early warning signals some of which are taken from the accounts.

As climate change impacts are felt at the local or regional level, provinces, municipalities and water boards currently develop climate resilient spatial development strategies. For this, information is used from the Dutch natural capital accounts and from the newly established urban and rural data centres that have been set up as satellites of Statistics Netherlands. These satellites help to streamline and coordinate data needs on climate adaptation between the central and local governments. For example, Rijkswaterstaat, the government organisation that manages waterways and dykes, has asked Statistics Netherlands to assess the status and trends of the ecosystem assets and ecosystem services for their (water)infrastructure, in order to better consider climate resilience in their decision-making processes. For this, they use the land accounts, ecosystem extent account, ecosystem condition account, and the supply and use tables of ecosystem services. This assessment considers the protection of the country's assets and people against flooding, as well as the ecosystem services provided by the river network and its surrounding areas that provide economic benefits. Moreover, it also pays specific attention to the long-term robustness of the river network.

Finally, three more general lessons are drawn from the examples. First, countries increasingly use the accounts for broader sustainability, green growth or wealth assessments. The EU Member States use the SEEA accounts for their broader sustainability and transition agendas. These agendas include climate change policy aspects, such as the transition to a low-carbon economy, green growth policies, the Sustainable Development Goals, the circular economy agenda, or resource efficiency and natural capital policies. Also, other countries or organisations stress the importance of the natural capital accounts as a basis for measures for sustainability, wealth or well-being. Examples include the NCA developments by the countries participating in the Gaborone Declaration on Sustainability in Africa, the World Bank Wealth of Nations report that uses NCA insights for showing developments in wealth (World Bank, 2018), or the Sustainable Development Goals that use NCA for monitoring many of their targets (see Ruijs et al., 2018).

Second, prioritising the selection of SEEA accounts to be compiled differs between countries and regions. Several aspects seem to explain this. One aspect is the existence of a legal framework, which obliges, for example, EU Member States to invest in certain accounts. Beyond that, the examples in Table 4 and the analysis in UNCEEA (2018) show that the focus on accounts that support mitigation policies, or accounts that support adaptation policies, differ across the world. Accounts that support mitigation policies are predominantly compiled in developed countries. They require air emissions accounts, energy flow accounts and material flow accounts for monitoring changes in their greenhouse gas emissions as well as to assess how to comply with UNFCCC targets at the lowest cost. They often also have EPEA and EGSS accounts for monitoring environmental activities, and environmental tax and subsidy accounts to monitor financial and economic consequences of for example the EU emission trading system and carbon taxes. Nevertheless, Table 4 shows that a growing group of countries in other parts of the world do compile accounts for their mitigation policies as well, such as Costa Rica, Ecuador, Colombia and China. They all use these accounts to monitor emission reduction from energy use. The accounts used for adaptation policies are compiled more often by the relative newcomers to NCA from the developing regions. Most of these countries start with accounts related to natural resources, such as land, water and forestry, as their economies more heavily rely on farming, fisheries and forest activities, all of which are impacted by climate change. Their first priority, therefore, in addition to poverty alleviation, is to properly manage their natural resources and to make their country more resilient to climate change.

Third, the survey amongst countries working on SEEA accounts revealed that several countries are positive about the institutional implications of implementing the SEEA accounts (see Appendix 2). Setting up the accounts provided a base for cooperation between the compilers and, for example, the environmental assessment organisations and research institutes. As a result, closer connections with the ministries that use these types of data have been established.

Table 4: Examples of climate-change-related SEEA accounts

COUNTRY	ACCOUNT TYPE [A]	M / A[B]	POLICY USE
AUSTRALIA[1]	CF: Land asset accounts for Great Barrier Reef and disaster recovery after a cyclone in 2011.	A	To measure impact from the cyclone.
AUSTRALIA[2]	CF: Physical water flow and asset account, with industry breakdown.	A	The accounts are used to analyse water allocation across the Murray Darling basin during drought, to find measures to minimise impacts from droughts. Water flow accounts indirectly used as input into forecasting models for water consumption and use to inform policymakers on future development and needs.
AUSTRALIA[+]	CF: Land, energy, water, carbon, agriculture, greenhouse gas and tax accounts are given by industry. Focus on flow accounts	M	The ABS accounts have been used indirectly, particularly the water and energy accounts. The National Greenhouse Accounts (not SEEA-based), produced by the Australian Government Department of the Environment and Energy, track emissions estimated at a national, state and industry level from 1990 onwards.
BOTSWANA[3]	CF: Water flow accounts with a breakdown by industry and water stock accounts.	A	Data are used as input for the economic diversity strategy, assessment of investments and water sector reforms. The water accounts inform the National Development Plan 2017–22, the National Strategy for Sustainable Development, the National Vision 2036, and ratification of the Gaborone Declaration for Sustainability in Africa (GDSA). Data are also used as input into forecasting models for water consumption and use as well as to monitor water assets.
BRAZIL[*]	CF: Water and land accounts. Plan to also develop timber and energy accounts. EA: Pilots for ecosystem accounts and future flows of ecosystem services.	A	Accounts used to calculate Green Domestic Product, which includes valuation of national ecological capital. Computation of the Green Domestic Product, must be aligned with SEEA.
BRAZIL[4,]	CF: Energy, water, land, timber, and air emission accounts	M / A	Used by the Presidents' cabinet and related ministries, to address the challenge 'of managing the huge tropical forest' and 'exploitation of assets of water, energy and materials' and considering carbon sequestration and resilience to climate change. Used for the annual assessment of its Green GDP, or an assessment of cross-border damages to the country's assets and causes to degradation impacting the poor. Also looking for priorities including PES schemes focusing on climate change aspects.
CANADA[+]	CF: energy use (flow) and greenhouse gas emission accounts, water flow accounts	M / A	The physical flow accounts and the water asset accounts have been used as part of the analysis leading to the development of Canada's policy on Clean Growth and Climate Change (CGCC). The accounts have been used to compile indicators on greenhouse gas intensity by industry and by commodity, which provide insight on performance of existing policies and the design of new ones. The water asset account supports the CGCC Framework by providing spatial data on water assets, quality and variability.
CANADA[5]	CF: Flow accounts for air emissions and energy use	M	Used to identify potential impacts on the environment resulting from a proposed trade agreement under negotiation, to assess likely environmental impacts of changes with help of SEEA Physical Flow Accounts, and for a decomposition analysis. greenhouse gas physical flow account is also used by the Environment Department for their reports to the UNFCCC.
CANADA[6]	carbon budget.	M	The Forest Service prepared a carbon budget for forests to inform better forest management, to monitor carbon budgets in forests and the relation between land use and emissions. It is used to assess for different management and climate conditions their impacts on carbon emissions. This carbon budget is not formally linked to the SEEA or integrated alongside other accounts.
CHINA P.R.[7]	CF: Asset and flow accounts for water, land, timber. EA: A pilot for air emissions accounts and other ecosystem accounts.	A	Given demand for integrated policies, the National Bureau of Statistics of China has adopted the SEEA as the statistical framework for measuring inter-relationships between the economy and the environment and plan to compile accounts in physical terms at national and provincial level from 2018 and onwards
COSTA RICA[*,8]	CF: Water asset and flow accounts by sector; Energy flow account by economic activity; SEEA-AFF for forest asset and flows and land use and quality.	M / A	Costa Rica monitors progress of the 2030 agenda for sustainable development, by monitoring trends in the relevant SDGs based on the SEEA accounts for water access, efficiency and stress (SDG 6); renewable energy and energy intensity by economic activity (SDG 7); and forest area share, sustainable managed forest and forestland degradation (SDG 15).

COUNTRY	ACCOUNT TYPE [A]	M / A[B]	POLICY USE
COSTA RICA[9]	SNA and SEEA-CF accounts used in Social Accounting Matrix for general equilibrium model. Mainly air emission accounts, but also environmental tax and energy accounts.	M / A	Accounts are input into the Integrated Environmental Economic Modelling for Costa Rica (IEEM-CR). Model used for forward-looking analysis of public policies, for given risk scenarios. Policy analysis on the effects of taxing high polluting products and on energy substitution in the transport sector.
COSTA RICA[10]	CF: Water Accounting	A	The Central Bank of Costa Rica applied Water Accounts in the water supply sector with the aim to show the usefulness of NCA for business. Water use and supply by industry for 2005–2013 was assessed with the aim to look at sustainability, water fee and PES.
DENMARK[11]	SNA & SEEA-CF accounts on air emissions; flow and asset accounts for energy, minerals, water, timber and waste; EPEA, EGSS and environmental taxes and subsidy accounts; EA: land asset accounts	M	Accounts used for monitoring indicators, such as 'intensity', 'resource productivity' or 'consumption of resources' based on water, energy and carbon accounts. Further, the SDG indicator on the ratio of land consumption to population growth and on hazardous waste generated per capita and proportion of hazardous waste treated by type. Indicators used for policy analysis of the interactions between the economy and the environment, particularly via a selection of five environment-economy integrated SDG indicators. SEEA data can be linked with Input-Output models to compile resource, environmental and carbon footprints.
EUROPE[12]	CF: land, materials, water, energy, carbon and thematic indicators. EA: Regulating, cultural & habitat services	M	SNA- and SEEA-based indicators for 'resource productivity', including water and carbon. Further thematic indicators estimated to monitor progress in key areas such as economic transformation, nature & ecosystems preservation, energy, food, buildings and transport. Used in the EU Growth strategy for 2010–2020 that searches for smart, sustainable and inclusive growth and aims at a resource efficient Europe. Monitoring is based on a scoreboard, with resource productivity the lead indicator.
EUROPE[13]	CF: several modules	M	SNA and SEEA used for compilation of SDG indicators, such as intensity or productivity, for several natural resources, residuals and emissions based on the related accounts. Also, environmentally extended input-output analysis using the environmental vectors from the accounts. Used for monitoring several SDGs, such as for water (SDG 6), energy (SDG 7), materials (SDG 8), greenhouse gas emissions per type of infrastructure (SDG9) or the total economy (SDG13). Also used for carbon footprint (SDG 17) and material footprint (SDG 8 & 12).
EUROPE[14]	CF: Air Emissions	M	Footprints for air emissions incorporated in products, based on air emissions accounts and economic input–output tables.
FRANCE [4]	CF: SEEA Forest Accounts, asset and flows EA: Supply & Use, range of Ecosystem services	A	The accounts are used to inform government decision-making in preventing the reduction of the forest cover e.g. for monitoring forest extent and to show the economic contribution by individual economic sectors such as forestry.
GUATEMALA[15]	CF: Energy, air emission EA: Biodiversity and Carbon Accounts	M / A	Guatemala uses NCA to monitor the impacts of climate change and search for sustainable management of firewood.
OECD COUNTRIES[16]	CF: air emission and energy flow accounts	M	Indicators developed on air emissions (production- and consumption-based) and energy use to monitor 'Green Growth' in each member country and identify trade-offs and win-win cases in managing natural capital. The Dutch 'Green Growth Monitor' follows the OECD Green Growth strategy and prescribed format.
NEPAL[*]	CF: Timber flow accounts and land asset accounts, incl. physical land cover account		SEEA is incorporated into the National Strategies for the Development of Statistics (NSDS) with high priority to monitor the country's natural resources.
NETHERLANDS[+]	CF: Air emission account, Energy PSUT, EGSS, EPEA, ReMEA, environmental tax and subsidies EA: carbon and ecosystem services accounts	M / A	The accounts are used in the Dutch climate policies, energy transition policies, circular economy programme and policies related to sustainability and the SDGs. They have primarily been used for monitoring, but also as input for scenario modelling. From the accounts, indicators have been compiled on greenhouse gas intensity, carbon footprint, employment and value added in the energy sector. They have also been used in trend analysis and footprint analysis. Data on the EGSS (sustainable energy sector) are used for the National Energy Outlook (published together with PBL Netherlands Environmental Assessment Agency), which is the basis for monitoring policies related to climate change and energy transition. Indicator data from SEEA related to climate change are incorporated in the Well-being Monitor of Statistics Netherlands.
NETHERLANDS[17]	CF: SEEA – Forest asset and AFF accounts EA: Carbon accounts	A	Accounts used for monitoring carbon sequestration. Also used for measuring Green Growth by using the results from several SEEA modules including forest accounts and AFF accounts.

COUNTRY	ACCOUNT TYPE [A]	M / A[B]	POLICY USE
NETHERLANDS[18]	CF: physical water flow and water emission accounts, on regional level	A	Water availability, water excess, water discharge, drainage, and flooding data used on the level of a medium-sized city, Zwolle. To study how existing data, including SEEA-Water data, can be used to adapt to climate change, and what new data in this field is need most.
NETHERLANDS[19]	CF & EA: SEEA accounts on air emissions, energy, EPEA, EGSS, subsidies, carbon permits. Both asset, flow and environ. activity accounts	M	Accounts used for preparing a factsheet about climate change facts for the Netherlands, to inform the Ministry of Economic Affairs. Factsheet includes figures from several SEEA accounts, including air emissions, energy, EPEA, EGSS, subsidies, carbon permits.
NETHERLANDS[20]	CF: energy, air emissions combined with NA: Supply & Use tables	M	Requested by the Ministry of Economic Affairs, a European comparative analysis was performed of the energy and greenhouse gas emission intensity of heavy manufacturing industries across Europe, while looking after industry structure and product mix.
NL-CARIBBEAN[21]	CF: & EA: SEEA framework applied	A	SEEA use for an assessment of climate change impacts and to identify adaptation needs. This includes monitoring the magnitude and quality of nature and the valuation of ecosystem services.
NORWAY	CF: air emission flow accounts per industry	M	Used to identify profile industries by combining economic output and greenhouse gas emissions in order to know who contributes the most, both in terms of economic value added and emissions.
RWANDA[22]	CF: land, water, mineral accounts EA: carbon, land, water provisioning accounts	A	Use of land cover maps and SEEA Land and Water Accounts in Ecosystem modelling. Assessment of the magnitudes of water flows, soil erosion and soil organic carbon stocks , in order to prioritise policies under the Green Growth Strategy and build capacity for ecosystem services assessment and policies.
SWEDEN[+]	CF: air emissions accounts, material flow accounts (MFA), EPEA, EGSS, environmental taxes and subsidies, consumption-based emissions accounts, land accounts	M	The environmental subsidies, the MFA and consumption-based indicators are part of the monitoring of the Swedish environmental goals. The data were used by the Ministry of Finance for preparing budgets and for policy analyses. Several organisations use the consumption-based data for analysing global consumption impact. The Swedish Energy Agency, the Swedish EPA and the Swedish consumer agency all ask for data for various purposes. The Swedish national institute of economic research uses data from SEEA accounts on air emissions, taxes and energy use for their economic model. The SEEA data are also used in research.
SWEDEN[23]	CF: air emissions accounts	M	Footprint analysis, based on an input-output analysis using the national accounts and air emissions accounts, showing emissions from Swedish consumption, combining domestic emissions and emissions caused elsewhere in the value. Information used for informing the Swedish environmental quality goals.
SWEDEN[+]	CF: energy and air emissions accounts	M	Accounts used to monitor fuel use and resulting CO^2 emissions from construction activity and the real estate industry. Used for monitoring the environmental quality goals by sector.
MEXICO[*+]	CF: EPEA, especially detailing CEPA class 'Other', which implicitly includes topics related to climate change mitigation	M	Results used for the environmental overview of the country, as part of the Environmental and Natural Resources Programme. SEAA accounts are also used for estimating the country's ecological net domestic product.
NEW ZEALAND[24]	CF: energy accounts and air emission accounts	M	The Treasury undertook analyses of a proposed carbon tax including the impact this would have on households (by income bracket, number of adults and children) and businesses.
FRANCE[+]	CF: air emissions accounts; physical energy flow accounts; environmental protection expenditure accounts (EPEA), including air and climate expenditure	M	Results used for the new Wealth indicators. Moreover, they have been used for indicators on CO^2 and greenhouse gas emissions per capita or per unit of GDP, and for the Carbon footprint (demand-based greenhouse gas emissions).
GERMANY[+]	CF: air emissions accounts, PEFA, MFA (sources and use of each subject material), EPEA and EGSS	M / A	EGSS data is provided annually to Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The Federal Environmental Agency (Umweltbundesamt, UBA) annually publishes reports containing indicators on greenhouse gas emissions from agricultural products, industrial energy use and greenhouse gas emissions, energy use and CO2 emissions of private households, raw material productivity, environmental taxes, and environmental protection expenditures. These data are used for environmental policies, for monitoring energy transition etc. In addition to that, data have been used in the 'Monitoring Report on the German Adaption Strategy to Climate Change'.
COLOMBIA[+*]	CF: air emissions accounts and environmental activity accounts with EPEA and REMEA	M / A	Accounts used to monitor mitigation policies related to reducing emissions from combustion of energy and industrials processes. Accounts are regularly produced since 2016, due to a regulatory decree of the National Statistical System. Accounts

COUNTRY	ACCOUNT TYPE [A]	M / A[B]	POLICY USE
			are used for policies related to monitoring water stocks and natural capital, and green employment. Further, SEEA-based indicators are used for the SGD, Colombian Green Growth Policy and the Solid Waste Integral Policy. SEEA accounts are also used as input in the Colombian CGE model for analysing climate change; e.g. used for estimating climate change finance and budget effects and for assessing environmental economic impacts from Climate Change.
RUSSIAN FEDERATION*, 25	CF: energy, water, minerals (pilot accounts)	A	A broad range of accounts with a focus on natural resources use and stocks, especially for estimating effects on future income. Less focus on climate change, although indirectly by assessing energy efficiency. Results are used at different governmental levels and sectors for decision-making.
SOUTH AFRICA+	CF: land accounts and energy asset and flow accounts, aquatic resources EA: ecosystem accounts in KwaZulu-Natal	M & A	Through development of Land and Ecosystem Accounts in KwaZulu-Natal and National River Ecosystem Accounts, the institutional cooperation between SANBI and Statistics South Africa has strengthened.
UGANDA[4]	CF: air emission accounts EA: carbon accounts	M	NCA used to learn about the shares of greenhouse gasses from agriculture, how to assess and reduce their emissions and how to prioritise policies among sectors and sub-sectors.
UNITED KINGDOM+, 26	CF: several SEEA-CF asset and flow accounts EA: supply & use of a range of ecosystem services	M	The accounts are firmly established in government decision-making at different levels, e.g. by showing the contribution of natural capital to individual economic sectors such as agriculture and forestry. Used to help governments to focus their budget and spending on priority areas of the country's and regional natural capital, including magnitude of carbon sequestration. NCA is part of the 25 Year Environment Plan. Carbon footprints are calculated but not yet used in policies.
UNITED STATES [27]	EA: mangrove accounts, condition accounts, soil accounts	A	NCA used to learn about the impacts from climate change for the US, such as flooding, storms and severe droughts leading to forest fires and losses.
UNITED STATES [27]	CF: air emission accounts EA: carbon accounts	M	Assess the air emissions generated by cattle; the accounts inform the policy process and help to prioritise policies.
ITALY[28]	CF: water asset and flow accounts	A / M	Water accounts used in a model for analysing climate change impacts in the Po River Basin. Used for assessing whether measures are needed to adapt to climate change risks related to drought and flooding, while water allocation should not change too much.
ITALY[29]	CF: air emissions accounts, SNA: tax accounts	M	Used to monitor costs or payments for emission permits issued by governments.
INDONESIA[30]	CF: air emissions, renewable energy accounts EA: carbon accounts	M / A	Indonesia has a low carbon development plan, connected to SDG 2030 roadmap, focusing on reducing greenhouse gas emission intensity. Further, it has a National Action Plan on adaptation that uses NCA information. A Systems Dynamics Modelling is applied using NCA and an Adjusted net-savings indicator is used for monitoring natural resource development due to climate impacts.
ZAMBIA [31]	CF: land, water, forest, etc. (future; energy and tourism) CF: water accounts (PSUTs for 2010–2016; plans for water asset and pollution tables	A	NCA used to monitor impact on honey production and trade-offs with other forest produce. The ministries and Parliamentarian Committee involved in WAVES want to know if and how climate change affects Zambia's natural resources. NCA also used to prioritize natural resource management and policies. Water Accounts are used to monitor impact and preservation of wetlands, enhance water flows to serve agriculture and hydro power.

Notes: (A) CF = SEEA Central Framework, EA = SEEA Ecosystem Account; (B) A = Adaptation, M = Mitigation

Note on sources: *The information in this table was compiled by the authors based on the survey sent to countries and literature reviewed.* + From own survey; * from UNCEEA (2018); 1) ABS, (2015, 2017); 2) Lound (2016); 3) WAVES Botswana (2016); 4) WAVES Third Policy Forum Paris 26–27 November 2018, personal communication; 5) http://www.international.gc.ca/trade-agreements-accords-commerciaux/env/env-ea.aspx?lang=eng and https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810009701; 6) Roberts (2016); 7) https://unstats.un.org/unsd/envaccounting/Brochure.pdf and https://seea.un.org/news/ecosystem-accounting-and-ecological-civilization-china; 8) WAVES Costa Rica, 2015; 9) Banerjee et al. (2017); 10) https://naturalcapitalcoalition.org/government-dialogue-best-practice-costa-rica-best-practice-on-water-accounting-for-decision-making-case-of-the-public-services-company-of-heredia/. 11) Eriksson (2018); 12) Fuente (2016); 13) national SDG reports of several European countries; 14) ec.europa.eu/eurostat/cache/metadata/en/env_ac_io10_esms.htm; 15) WAVES Guatemala, 2014. 16) OECD (2011, 2017b); 17) Statistics Netherlands (2015, 2017b); 18) Kist (2018); 19) Statistics Netherlands (2017c); 20) Statistics Netherlands, 2018 (to be published); 21) https://www.wolfscompany.com/projects/ and personal communication with Esther Wolfs; 22) https://snappartnership.net/teams/rwanda-natural-capital-accounting/; https://www.wavespartnership.org/en/rwanda-launches-

first-natural-capital-accounts-inform-economic-planning. 23) Steinbach (2016); 24) Webb et al., 2016; 25) Fomenko and Fomenko (2018) and Tatarinov (2018); 26) Connors (2016); 27) John Matuszak, US, November 2018, personal communication; 28) Pedro-Monzoísa et al. (2016); 29) Recchini (2016); 30) https://www.wavespartnership.org/en/indonesia and personal communication during the Third Natural Capital Policy Forum; 31) https://www.wavespartnership.org/en/early-results-show-value-nca-development-policies-zambia.

5 Conclusions

This report provides an overview of potential and current use of the SEEA natural capital accounts for climate-change-related policy uses. Globally, climate change is high on the societal and political agendas. Many parties are searching for solutions — for mitigation measures to reduce greenhouse gas emissions as well as for adaptation measures making countries less vulnerable to the impacts of climate change. This paper shows that, as climate change affects almost all areas of society and government, nearly all natural capital accounts (from the SEEA Central Framework and the SEEA Ecosystem Accounts) are relevant for climate-change-related policies and assessments. As such, the key question for users and producers of these accounts is where to start? Which accounts are most relevant for the most pertinent policy questions?

In this report, we distinguish between mitigation- and adaptation-related policy questions. The examples show that many countries have already adopted a set of SEEA accounts that are relevant for informing mitigation policies. Nowadays, monitoring trends in greenhouse gas emissions per sector and type of greenhouse gas is common practice in nearly all the countries that compile accounts. For this reason, air emissions accounts are among the most popular accounts. Many countries also monitor expenditures on climate change mitigation and on policies aimed at 'greening' the economy using Environmental Protection Expenditures Accounts and Environmental Goods and Services Accounts. As much policy attention goes to reducing emissions from fossil fuel use, many countries compile energy accounts. They provide the relevant information to monitor trends in renewable energy use or energy efficiency, to identify structural economic changes or to prepare carbon taxes, emission trading schemes or renewable energy subsidies. So far, accounts have been used less for reducing emissions related to LULUCF, the agricultural sector, waste handling or international trade. Some interesting examples, however, show that policy-relevant uses are possible for these themes, as well; for example, see a Swedish footprint analysis of greenhouse gases incorporated in consumption, Indonesian peatland accounts, and several countries that estimate carbon sequestration in forests and agricultural land.

The second category of policy questions is related to climate change adaptation. The examples reviewed show that, so far, only a limited number of countries use the natural capital accounts for their adaptation actions. Countries such as Australia, Botswana and the Netherlands show that monitoring a country's resilience to climate change impacts or preparing adaptation policies benefits from the information in the natural capital accounts. For instance, in the Netherlands, adaptation policies aiming for reducing economic damages from flooding or water scarcity, use information from the water, material flow and agricultural accounts. Depending on the adaptation question to be tackled, relevant data may come from the land, water, forest, aquatic, energy (asset), soil accounts from the SEEA Central Framework or ecosystem services and assets accounts from the SEEA Ecosystem Accounts. For adaptation questions related to flood damage in coastal zones or to urban adaptation needs, data from economic asset or regional accounts from the System of National Accounts are equally relevant. However, despite the international attention to these topics, to our knowledge, only few countries have used the accounts for these types of analyses. One reason may be that spatial disaggregation of the accounts is not yet sufficiently detailed or accurate enough for policy use. Another reason may be that the urban adaptation questions are raised by subnational authorities who are less familiar with the natural capital accounts. The example from the Netherlands shows that reaching out to subnational users, for example through regional data centres, creates new demand and uses for accounting information. In this, the role of universities has been very important in both the Netherlands and Australia.

The accounts provide useful inputs into data intensive policy analyses using statistical, econometric or modelling techniques. Some examples of countries or organisations using the accounts for scenario and outlook studies exist. Such studies provide policy-relevant insights in expected

developments of climate change and energy and natural resources use. But, use of accounts for these purposes still appears limited. The European Union and its Member States are frontrunners here, probably because a broad range of accounts are available for all Member States over a series of years, which enables more and more elaborate benchmarking and analytical uses. The European Union also has a history of evidence-based policy-making (Wilson, 2015), which creates demand for uniform and coherent data sources.

A key finding of this review is that there is still a gap between potential and current use of the natural capital accounts for climate-change-related policies. To advance the application of natural capital accounting in policy design and evaluation, it is important that users, producers and analysists of the accounts jointly decide on the most relevant policy questions and accounts. This implies a process that not only includes the departments directly involved in climate change policies, such as those working on energy, agriculture and water, but also those whose sectoral policies indirectly impact, or are impacted by, climate change, such as housing, infrastructure, mining and nature.

As almost all natural capital accounts are useful, it is important not to be overwhelmed, but to choose wisely and start by developing accounts that can be used for the most urgent policy questions and policy instruments that are most likely to be used. Experiences in the European Union show that, once accounts are being compiled and used for relevant policy issues, a snowball effect may occur, leading to an increased demand for more accounts and policy analyses. A legal mandate to compile these accounts helps to create this demand.

This review also shows that developing and developed economies have a different focus in the types of climate-change-related accounts being compiled. Developing economies focus more on natural resources accounts, such as those for land, water, forest, agriculture and minerals, which are especially used for questions related to climate change adaptation. The developed economies focus more on the emission and energy accounts, used to inform mitigation policies. For the moment, there is a logic for this, as the majority of emission reductions have to come from developed economies, whereas the developing economies more strongly feel the impact of climate change on their availability of natural resources. For developing economies to choose a clean development path, it is, however, important to equally monitor changes in their energy mix and greenhouse gas emissions. Likewise, as developed economies also suffer from the impacts of climate change, it is important for them to also compile accounts that help to define adaptation policies. So, countries from both types of economies can learn from each other on how to use the natural capital accounts for better decision-making.

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Appendix 1: CEPA / CReMA categories

The CEPA, Classification of Environmental Protection Activities, as recommended by SERIEE is composed of 9 classes, whereas CReMA, the Classification of Resource Management Activities, consists of 7 main classes. The SEEA-CF (Table 4.1; 2014), recommends both. This preliminary classification has the following structure:

	The **CEPA** general structure is as follows:
CC.	1: Protection of ambient air and climate
CC.	(1.1 Protection of air & climate, prime focus on climate; only in this pilot project, with a test on the data)
	(1.2 Protection of air & climate, prime focus on ambient air; only in this pilot project, with a test on the data)
CC.	2: Wastewater management
CC.	3: Waste management
CC.	4: Protection and remediation of soil, groundwater and surface water
	5: Noise and vibration abatement
CC	6: Protection of biodiversity and landscape
	7: Protection against radiation
	8: Research and development
	9: Other Environmental Protection activities

	CReMA, The Classification of Resource Management Activities. This preliminary classification has the following structure:
	10: Management of water resources
CC.	11: Management of natural forest resources
	11 A: Management of non-cultivated forest areas
	11 B: Minimisation of the intake of forest resources
CC.	12: Management of wild flora and fauna
CC.	13: Management of energy resources:
	13 A: Production of energy from renewable sources
	13 B: Heat/Energy saving and management
	13 C: Minimisation of the intake of fossil resources as raw material for other use than energy production
	14: Management of minerals
	15: Research and development activities for natural Resource Management
	16: Other natural Resource Management activities

Source: Eurostat, 2008; SEEA-CF (2014; partly), Classification of Environmental Activities (CEA), P.267; Ramon, 2014; Classification of Environmental Activities (CEA), 2011; Eurostat, 2012, Taskforce, special sub-group on Environmental activity classification; slight adjustments and additions by Statistics Netherlands (2014).

Appendix 2: Summary of the SEEA survey results

1. WHICH ACCOUNTS HAVE BEEN PRODUCED IN YOUR COUNTRY THAT RELATE TO CLIMATE CHANGE ADAPTATION OR MITIGATION? PLEASE PROVIDE DETAILS ABOUT THE TYPES OF ACCOUNTS.	
NETHERLANDS	Statistics Netherlands compiles air emissions accounts (annual and quarterly data), Physical energy supply and use tables, Environmental Goods and Services Sector (EGSS), Environmental Protection Expenditure Accounts (EPEA). and Resource Management Expenditure Accounts (ReMEA), Environmental taxes and subsidies accounts, Carbon accounts and Ecosystem services accounts.
SWEDEN	Statistics Sweden complies air emissions accounts (annual on a national (including fossil/biofuels use in TJ) and regional level, quarterly accounts at national level), Environmental protection expenditure accounts (EPEA). A methodology was developed on behalf of the European Commission, a few years back, on climate change adaptation expenditures, but this has not been implemented, nationally. Moreover, Statistics Sweden compiles accounts on taxes and subsidies, EGSS, consumption-based climate change emissions and land accounts.
MEXICO	The Economic and Ecological Accounts of Mexico (SEEA-México) include the Expenditures on Environmental Protection (EPEA). The class 'Other for environmental protection', implicitly includes topics related to climate change mitigation, e.g. the public transport investment in order to reduce the CO_2 emissions.
FRANCE	Air emissions physical accounts, Physical energy flow accounts, Air and climate protection expenditure accounts are compiled.
GERMANY	The German Environmental protection expenditure accounts (EPEA) provide information about expenditures concerning 'Protection of ambient air and climate' (CEPA 1). Data is available for the general government and for non-specialised producers of ancillary services. It is not possible to separate expenditure for the protection of climate from the protection of ambient air. The module environmental goods and services sector (EGSS) provides data on turnover, exports, gross value added and employment of corporations — except corporations of the agricultural sector — concerning protection of climate and ozone layer (CEPA 1.1.2 and 1.2.2). There are also the physical flow accounts on materials, energy and emissions which provide information on sources and use of each commodity.
AUSTRALIA	The following SEEA Accounts have been produced by the Australian Bureau of Statistics: 1) Energy accounts (annual time series from 2008-09): physical supply and use tables; monetary supply and use tables; 'hybrid' supply and use tables which provide a combined presentation of the supply and use of energy by industry and households in physical and monetary terms; energy indicators; and physical and monetary energy assets tables. 2) Water accounts (annual time series from 2008-09): physical supply and use tables; monetary supply and use tables; water indicators. 3) Land accounts (selected jurisdictions on an irregular basis): land cover; land value; land use. 4) Carbon accounts (one-off publication): Biocarbon stock accounts for the Great Barrier Reef region (1989-2016). 5) Agricultural accounts (one-off publication for 2011-2016): SEEA Agriculture, Forestry and Fisheries accounts for Australia. 6) Greenhouse gas emissions accounts (2004-05 to 2015-16): Published in Australian Environmental-Economic Accounts, 2018. 7) Environmental taxes (2003-04 to 2015-16): Published in Australian Environmental-Economic Accounts, 2018. It is also worth noting the following accounts (not produced by the ABS and not SEEA-compliant) have been produced in Australia: 8) Carbon accounts, using the 'full carbon accounting model (FullCAM)', produced by the Australian Government Department of the Environment and Energy. 9) the National Greenhouse Accounts, produced by the Australian Government Department of the Environment and Energy (more information below). 10) the National Water Account, produced by the Australian Bureau of Meteorology
COLOMBIA	Colombia is compiling environmental activities accounts, containing Environmental Protection Expenditure and Resources Management Expenditure (EPEA/ReMEA) for the government, industries and public services, from 2009 to 2017. In 2018, jointly with the National Planning Department and Ministry of Environmental and Sustainable Development, DANE, the national statistical agency, harmonised methods, information sources and treatment of statistical information and environmental-economics accounts, that were used to estimate climate change finance with the MRV model. Moreover, DANE compiled air emissions accounts, containing emissions by combustion of energy and industrials processes. These were used for monitoring climate change mitigation. In 2018, DANE worked with the Institute of Hydrology, Meteorology and Environmental Studies to harmonise the *treatment of statistical information used in the national inventory of greenhouse gases and environmental economics accounts.*
SOUTH AFRICA	Land and Ecosystem Accounting in KwaZulu-Natal, and Energy Accounts.
UNITED KINGDOM	Defra publishes annual data on carbon footprint of the UK:
ZAMBIA	So far, physical supply and use tables for water (PSUTs) for the period 2010-2016 have been compiled. There are plans to compile the water pollution tables and asset tables for the same period. Furthermore, steps are being undertaken to have the water accounts produced annually.
CANADA	StatCan produces annual energy use, and greenhouse gas emission accounts, as well as a biennial water use accounts, all at the national level. Data are compiled by industry, commodity and final demand categories (direct and indirect) and presented as industry totals. They are working on producing energy and greenhouse gas physical flow accounts (PFA) at the provincial level. As of September 2017, PFA for energy use is being compiled at the provincial/territorial level. Sub-national greenhouse gas estimates are expected to be released shortly. Water yield data (our water asset account) over time are also produced and provide some information with regards to climate change.
COSTA RICA	The Central Bank in Costa Rica is currently working on the experimental ecosystem account for carbon sequestration, using information for the period 2013-2014 from the National Forest Inventory.

2. HAVE THE ACCOUNTS BEEN USED IN POLICY PROCESSES RELATED TO CLIMATE CHANGE MITIGATION OR ADAPTATION?
A. WHAT POLICY NEEDS HAVE THE ACCOUNTS HELPED ADDRESS? HAVE THEY BEEN USED FOR PROBLEM IDENTIFICATION, POLICY PREPARATION, POLICY REVIEW OR MONITORING?
B. WHICH INDICATORS WERE BASED ON THE ACCOUNTS?
C. HAVE THE ACCOUNTS BEEN USED IN ADDITIONAL ANALYSES, SUCH AS TREND ANALYSIS, MODELLING, EX ANTE POLICY ANALYSIS OR ANY OTHER ANALYSIS?

NETHERLANDS	The accounts are used in the Dutch climate policies, energy transition policies, circular economy programme and policies related to sustainability and the SDGs. They have primarily been used for monitoring, but also as input for scenario modelling. From the accounts, indicators have been compiled on greenhouse gas intensity, carbon footprint, employment and value added in the energy sector. They have also been used in trend analysis, footprint analysis, and scenario analysis.
SWEDEN	The Swedish data, such as the environmentally motivated subsidies, the MFA and consumption-based indicators, are part of the monitoring of the Swedish environmental goals, especially the 'generation goal' — *A society in which the major environmental problems in Sweden have been solved … without increasing environmental and health problems outside Sweden's borders.* The data was used by the Ministry of Finance in their work on the spring budget (Appendix 3 – Bilaga 3 Miljö). The Ministry of Finance has also expressed that the web-tool that Statistics Sweden publish with all SEEA data for further analysis is useful in their policy analyses. Moreover, several organisations in Sweden have used the consumption-based data for further analysis of the global consumption impact. The Swedish Energy Agency, the Swedish EPA and the Swedish consumer agency all ask for data for various purposes, either annually or on ad-hoc basis. The Swedish national institute of economic research receives some of the SEEA account annually for their economic model, EMEC, e.g. air emissions, taxes and energy use by industry. The data from the accounts is also used in research. Some use what is available online free of charge and others ask for some additional tweaks and even microdata level data. Data are usually energy, air emissions, taxes and environmental protection expenditures. Some continue the research on consumption-based data.
MEXICO	The accounts are used for the environmental overview of the country, in the frame of the Environmental and Natural Resources Programme (PROMARNAT). Based on the accounts an indicator on loss of natural capital has been estimated. The accounts have been used for the 'Estimaciones del impacto del cambio climático, desde el Sistema de Cuentas Económicas y Ecológicas de México 2010-2100' from the Environmental and Natural Resources Ministry (SEMARNAT).
FRANCE	The environmental accounts have been used for estimating the new Wealth indicators. Moreover, they have been used for indicators on CO_2 and greenhouse gas emissions per capita or per unit of GDP, and for the Carbon footprint (demand-based greenhouse gas emissions).
GERMANY	Data on EGSS is provided annually to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). In principle, data can be used by all ministries but there is no clear evidence about which data are used. The Federal Environmental Agency (Umweltbundesamt, UBA) annually publishes 'data on the environment' (Daten zur Umwelt). This indicator set contains, among others, data on greenhouse gas emissions from agricultural products. Furthermore, UBA has assembled a 'core indicator set', which contains e.g. industrial energy use and greenhouse gas emissions, energy use and CO2 emissions of private households, raw material productivity, environmental taxes, and environmental protection expenditures. These indicators are compiled by the Federal Statistical Office and are based on SEEA accounts. These data are used for environmental politics, for monitoring energy transition etc. They serve as a source of information for, among others, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). In addition to that, analyses have been used in the 'Monitoring Report on the German Adaption Strategy to Climate Change' (Monitoringbericht zur Deutschen Anpassungsstrategie an den Klimawandel (2015)) by the Federal Government.
AUSTRALIA	The ABS SEEA accounts have not been used directly in policy processes, but it is assumed that the ABS accounts have been used indirectly, particularly the water and energy accounts. The National Greenhouse Accounts (not SEEA-based), produced by the Australian Government Department of the Environment and Energy, track emissions estimated at a national, state and industry level from 1990 onwards. The data is used to meet Australia's reporting commitments under the United Nations Framework Convention on Climate Change, track progress against Australia's emission reduction commitments, and inform policymakers and the public.
COLOMBIA	Actually, the environmental economic accounts produce approximately 30 indicators related to different topics that comply with the SEEA recommendations. These indicators are available at: http://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-satelite/cuenta-satelite-ambiental-csa/cuenta-satelite-ambiental-csa-indicadores. Moreover, the environmental economic indicators are used to monitor progress of the SGD, the Colombian Green Growth Policy and the Solid Waste Integral Policy. Moreover, they are an input for the Colombian Computable General Equilibrium Model for Climate Change.
SOUTH AFRICA	The accounts are not used for policy or indicator development at this stage as the accounts are still discussion documents.
UNITED KINGDOM	Not yet
ZAMBIA	The water account has helped to identify the issue that most water used by households is derived from boreholes, which means that household are exposed to untreated water and potentially water-borne diseases. The other issue is that though households accounted for the large portion of water use, it was industry that paid for the bulk of the water consumed. The initial draft results are being used to develop models for water and forestry accounts by the Modelling TWG.
CANADA	The PFA have been used as part of the analysis leading to the development of Canada's policy on Clean Growth and Climate Change. The Water Asset data have been used as part of the Pan-Canadian Framework on Clean Growth and Climate Change. The accounts have been used to compile indicators on greenhouse gas intensity by industry, as it can provide insight on performance of existing policies and the design of new ones. Also, greenhouse gas intensity per commodity has been provided, as it is helpful in the case of emission-intensive, trade-exposed sectors. The water asset accounts support the Pan-Canadian Framework on Clean Growth and Climate Change by providing spatial data sets on water assets, water quality and water variability
COSTA RICA	Not yet

3. HAVE THE ACCOUNTS INFLUENCED DECISIONS MADE OR THE ADOPTION OF POLICIES RELATING TO CLIMATE CHANGE ADAPTATION OR MITIGATION?

NETHERLANDS	Data on EGSS (sustainable energy sector) are used for the National energy outlook (published together with PBL Netherlands Environmental Assessment Agency), which is the basis for monitoring and policy review in the Netherlands of policies related to climate change and energy transition. Data on indicators from SEEA related to climate change are incorporated in the Monitor of Well-being published by Statistics Netherlands. This annually publicised report is an assessment of well-being in the Netherlands, which is not merely based on gross domestic product (GDP), but also takes other indicators into account, including environment, health, education, labour, security, trust and inequality. This report is made at the direct request of Dutch Cabinet.
SWEDEN	It is very hard to know whether the accounts have influenced decisions as they are part of general discussion and insight where we are right now. The data is also available free of charge on our web-site making it difficult to know the in-depth aspects of the policy cycles or how researchers impact on policy advisors.
MEXICO	No information available
FRANCE	No information available
GERMANY	No information available
AUSTRALIA	The accounts have not directly influenced policy, but it is assumed that the ABS accounts have been used indirectly, particularly water and energy accounts. However, in the Australian Government publication 'Environmental Economic Accounting — A Common National Approach, Strategy and Action Plan' (April 2018), it is stated that 'the SEEA frameworks will enable for several of the sustainable goals and targets to be measured using robust common indicators', listing as one of these Target 2.4 'Ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.'
COLOMBIA	No information available
SOUTH AFRICA	None at this stage as the accounts are still discussion documents.
UNITED KINGDOM	No information available
ZAMBIA	Not as yet because they still have to be finalised first
CANADA	No information available
COSTA RICA	No information available

4. IS THE SEEA MENTIONED IN ANY LEGISLATION RELATED TO CLIMATE POLICIES? PLEASE SPECIFY.

NETHERLANDS	No information available
SWEDEN	No information available
MEXICO	The Climate Change General Law states that: a) Art. 22. Section. XV. Contributes to the Ministry administrative units, in order to quantify the cost of environmental pollution and natural resources depletion made by economic activities in order to value the ecological net domestic product; and b) Art. 77. Section. VI. The valuation of cost attributed to climate change in a certain year, which will be included into the ecological net domestic product. In both cases, the Mexican ecological net domestic product is compiled from the applied recommendations by the SEEA, since its 1993–2012 version.
FRANCE	No information available
GERMANY	No information available
AUSTRALIA	No information available
COLOMBIA	SEEA is not mentioned in any law. In 2017, policy documents on green growth and solid waste mention the need to set up environmental economics accounts, to monitor environmental policy.
SOUTH AFRICA	None at this stage as the accounts are still discussion documents.
UNITED KINGDOM	No information available
ZAMBIA	No information available
CANADA	No information available
COSTA RICA	No information available

5. HAS IMPLEMENTATION OF THE SEEA RESULTED IN THE ESTABLISHMENT OF NEW INSTITUTIONAL MECHANISMS AND ARRANGEMENTS? HAS THIS IMPACTED HOW THE ACCOUNTS ARE USED FOR POLICIES RELATED TO CLIMATE CHANGE MITIGATION OR ADAPTATION? THIS MAY INCLUDE, BUT IS NOT RESTRICTED TO, FOR EXAMPLE NEW INSTITUTIONAL COOPERATION, NEW BUDGETARY RULES OR NEW POLICY-MAKING PROTOCOLS.

NETHERLANDS	Statistics Netherlands works closely together with PBL Netherlands Environmental Assessment Agency to publish the annual Energy outlook publication.
SWEDEN	Publishing the consumption-based statistics enabled the discussion on our impact on global greenhouse gas emissions, on a policy level. There have been several organisations that have used these statistics and elevated the discussion to the policy level.
MEXICO	No information available
FRANCE	No information available
GERMANY	The implementation of SEEA resulted in a more intensive cooperation with the German Environment Agency (UBA) and the Institute of International Forestry and Forest Economics of Thünen Institute (TI).
AUSTRALIA	The Australian Government recently finalised and published a strategy and action plan for a common national approach to SEEA-based Environmental Economic Accounting. The strategy sets out how a common national approach to the implementation of the United Nations System of Environmental-Economic Accounting will provide coherent and integrated data for decision-making by governments, business and the community. It is too early for this strategy to have had an impact on how the accounts are used for policies related to climate change mitigation and adaptation, however the potential is certainly there.
COLOMBIA	In 2016, Colombia established a regulatory decree of the National Statistical System. It is an instrument to regularly produce statistical information. Policymakers recognise the need of the new

	technical advances in environmental economic accounting, and this has been incorporated in the action plan of the institution. These needs relate to water stocks, economic valuation of natural capital, material flow accounts, green employment, etc.
SOUTH AFRICA	Through the development of the Land and Ecosystem Accounting in KwaZulu-Natal, and National River Ecosystem Account, there was the development and strengthening of the institutional cooperation between SANBI and Stats SA.
UNITED KINGDOM	No information available
ZAMBIA	No information available
CANADA	No information available
COSTA RICA	No information available

6. IS THE SEEA USED FOR OR MENTIONED IN YOUR INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC) TO THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)? IF SO, PLEASE ELABORATE.

NETHERLANDS	No
SWEDEN	No. The work on the UNFCCC reporting is done at Statistics Sweden on commission from the Swedish EPA who are responsible for this work. This is not part of the SEEA-group.
MEXICO	No
FRANCE	No
GERMANY	The EU and its Member States communicated a common INDC report. SEEA is not mentioned.
AUSTRALIA	Not the SEEA, however, the National Greenhouse Accounts (not SEEA-based), produced by the Australian Government Department of the Environment and Energy, are used to meet Australia's reporting commitments under the United Nations Framework Convention on Climate Change, track progress against Australia's emission reduction commitments, and inform policymakers and the public.
COLOMBIA	No, in Colombia the official information reported to the UN Framework Convention on Climate Change is related to the national inventory of greenhouse gases realised by Institute of Hydrology, Meteorology and Environmental Studies IDEAM.
SOUTH AFRICA	Yes
UNITED KINGDOM	No
ZAMBIA	No. Knowledge of the SEEA is limited among relevant professionals.
CANADA	No information available
COSTA RICA	No