LG/15/23

15th Meeting of the London Group on Environmental Accounting
Wiesbaden, 30 November – 4 December 2009

SEEA as a framework for assessing policy responses to climate change

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1. Introduction

Climate change is high on the political agenda at all levels. In the scientific world there is general consensus that economic and social pressures are contributing to climate change. Accelerating emissions of carbon dioxide, methane, and other greenhouse gases since the beginning of the 20th century have increased the average global temperature by about 0.74°C and altered global precipitation patterns (IPCC, 2007). Climate change is already affecting economic activities throughout the world. In the future, the impacts on society, the economy and the environment will only increase. There is thus a high demand for good statistics that can support the measurement and analysis of the drivers, the social and economic consequences of climate change and the related mitigation and adaptation measures (UN, 2008). Several efforts have been undertaken by the statistical community to specify how statistics may be used for climate change related measurement, policy making, and to identify recommendations and actions to streamline the climate change aspect in

Remarks:
The views expressed in this paper are those of the author and do not necessarily reflect the policies of Statistics Netherlands.

Project number:
BPA number: *-CBO*
Date: *5 August 2009*

official statistics (ABS, 2009). In this regard, environmental accounting has been put forward as a framework to integrate relevant statistics on climate change.

The system of Integrated Environmental and Economic Accounting (SEEA) has been developed to integrate environmental and economic information in one common framework (UN et al., 2003). An important characteristic of environmental accounting is that the data are consistent with the System of National Accounts (SNA). The environmental data can be directly compared to macro-economic indicators such as GDP. The system of integrated environmental accounts is a useful tool for monitoring, measuring and analyzing the relationship between environmental policies and the economy by providing consistent time series of data, tables and accounts. The system of environmental accounts is still under development. Currently, a revision is undertaken of the SEEA in order to upgrade the system to a statistical standard in 2012.

Environmental accounting can be used to monitor and analyse a wide scale of environmental issues, including climate change. The main goal of this study is to identify the parts of SEEA that contain relevant information with regard to climate change. The potential of environmental accounts is investigated to provide a consistent framework for measuring the different aspects of climate change. The set of different accounts which are accordingly identified, will tentatively be named "climate change accounts". The general idea is that the accounting framework can serve as a basis to bring together the different aspects of climate change. However, it is important to stress that basic statistics (i.e. emission inventories, energy balances, business statistics etc.) remain essential both as a source for the climate change accounts and for further analyses. Components of climate change accounts will not be limited to the environmental accounts. As the National accounts serve as the central framework, also other satellite accounts with relevant data can be incorporated into the climate change accounts, such as tourism accounts and health accounts.

In this study we focus on the interrelationships between economic activities and climate change. Other important aspects, such as specific social issues in relation to climate change or the impacts of climate change on nature, will not be discussed in this study[1]. Measurement of the extent and direct impact of climate change on the physical environment is largely based on data sources outside the official statistical system. These sources include meteorological and hydrological information, different physical environmental data and data from scientific research. The social aspects of climate change will be outside the scope of the present study, although they could in principle be integrated within the general framework of accounts.

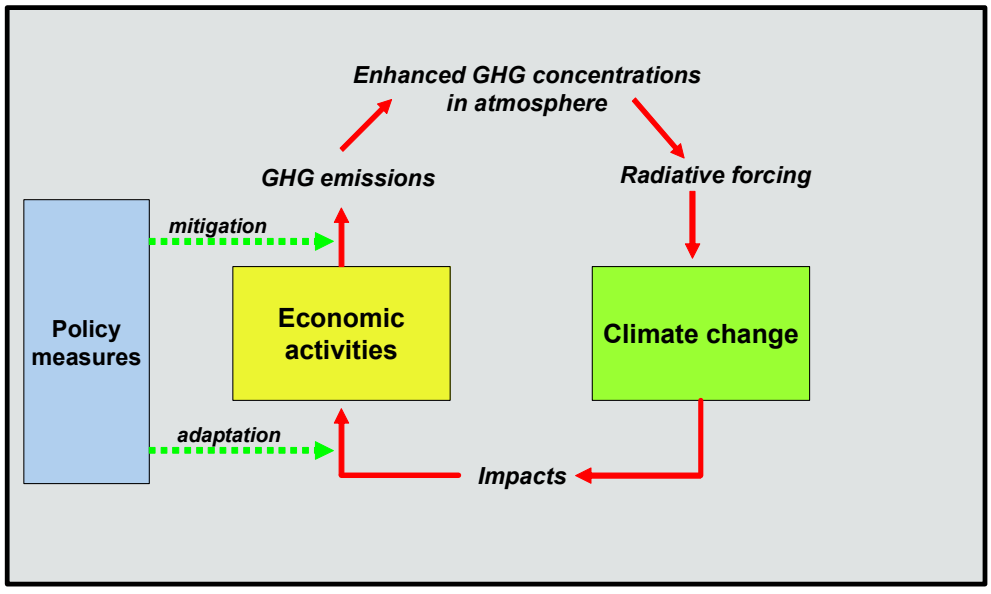
[1] The impact on nature is only partly discussed in relation with the ecosystem accounts.

This study is structured as follows. In paragraph 2 the general relationship between climate change and the economy is discussed within the context of the DPSIR (Driving forces-Pressure-State-Impact-Response) model. In paragraph 3 the parts of SEEA, as well as other satellite accounts, that are relevant with regard to climate change are identified. In paragraph 4 we will integrate the relevant accounts into the DPSIR model. Paragraph 5 will specifically address the Dutch situation. Issues particularly important for the Netherlands will be identified, in order to specify what accounts could be compiled as a meaningful basis for the Dutch climate change accounts. Also, areas that need further development will be identified. Paragraph 6 will round up with some conclusions and recommendations.

2. Climate change and the economy

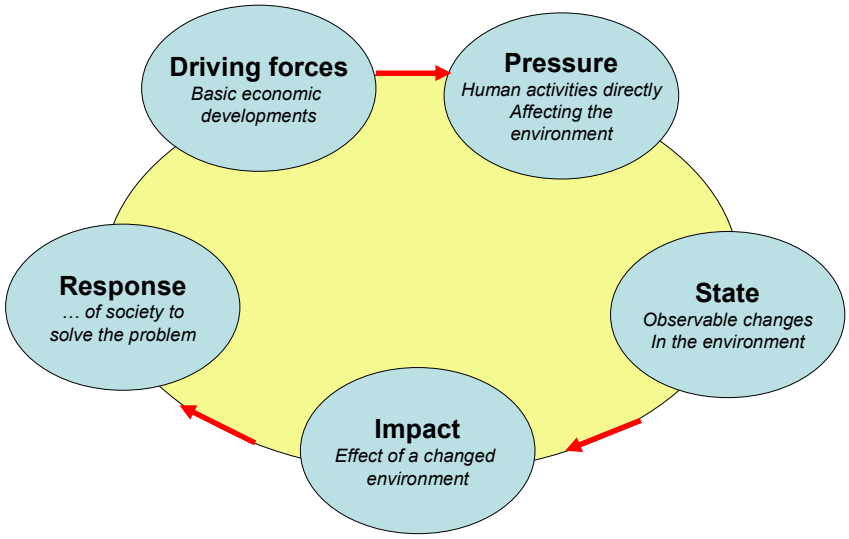
Climate change and the economy are closely interconnected (Figure 2.1). There is abundant scientific evidence that the emission of greenhouse gasses (GHG) caused by economic activities contributes to climate change (e.g. IPCC, 2007). Combustion of fossil fuels, deforestation, but also specific agricultural activities and industrial processes are the main drivers of the increased emission of greenhouse gasses. Enhanced concentrations of greenhouse gasses in the atmosphere will by radiative forcing increase global temperatures. Likewise has climate change a direct impact on all kind of economic processes. These impacts can be both positive and negative. Policy makers may respond to the climate change by mitigation and adaptation measures, which in turn directly or indirectly influence economic activities.

Figure 2.1: The interrelationships between the economy and climate change



A common way to assess and manage environmental problems is the so-called Driving forces-Pressure-State-Impact-Response framework (DPSIR)[2] (Figure 2.2). Driving forces are the socio-economic forces driving human activities, which increase or mitigate pressures on the environment. Pressures are the stresses that human activities press on the environment. State, or state of the environment, is the condition of the environment. Impacts are the effects of environmental degradation on society, the economy and ecosystems. Responses refer to the responses of society to the environmental situation. This framework is very helpful to organise information on the state for the environment, both for researchers, policy makers and the general public. Specific indicators can be complied for each part of the DPSIR framework. Here, we will describe climate change and its relations with the economy using the DPSIR model[3].

Figure 2.2: the DPSIR framework



Driving forces of climate change

Basic economic developments are the main drivers behind human induced climate change. Increased production of goods and services, changes in the production structure, increased transportation, a higher demand for all kind of consumer goods, all contribute to a higher pressure on the atmosphere with regard to the greenhouse

[2] The DPSIR framework is widely applied internationally, among others by the EEA, UNEP and the OECD.

[3] As stated in the introduction, we will focus here on the interactions between economic development and climate change, i.e. omitting the social dimension (e.g. driving forces directly related to population growth) or the environment in a broader sense (e.g. pressure caused by natural sources, impacts on biodiversity, etc.). The DPSIR model, however, can easily be elaborated to include all these other interactions.

gas concentration. Particularly important is of course the ever increasing demand for energy. At present the world's economy runs on fossil fuels. The combustion of coal, oil and natural gas and derived products provide energy to nearly all economic activities. The emission of CO_2 is a residual product of burning these fossil fuels. Also changes in land use pattern, deforestation and land clearings are important driving forces leading to a rise in CO_2 emissions.

Pressure: greenhouse gas emissions

The pressures related to climate change are the greenhouse gas emissions caused by economic activities[4]. CO_2 is by far the most important greenhouse gas, and originates mainly from the combustion of fossil fuels and biomass. However, also other greenhouse gasses like methane, nitrous oxide and halocarbons contribute to climate change. Methane is mainly produced by domesticated animals such as dairy cows, pigs etc, rice growing, gas flaring and mining activities. Nitrous oxide mainly originates from agricultural land management, animal manure management, combustion of fossil fuels, and the production of fertilizers and nitric acids.

State

The state of the environment with regard to climate change is the condition of the atmosphere and hydrologic system of the earth. This state can be described using the so-called essential climate variables (ECV's) (GCOS, 2009; UNEP, 2008). Within the atmospheric domain these are air temperatures, air pressure, precipitation rates, surface radiation budget, but also the concentration of the different greenhouse gasses. In the oceanic domain these are sea surface temperatures, salinity, sea level, sea ice, ocean current etc. In the terrestrial domain these are river discharge, ground water levels, lake water levels, land cover (including vegetation type), glaciers, etc. The essential climate variables directly support the work of UNFCCC and IPCC.

The impact of climate change on the economy

Climate change has the potential to create a wide range of economic impacts. In all likelihood all sectors of the economy will be affected. Some impacts will gradually affect economic processes, such as the effect of increasing temperature on energy demand, whereas others may come as a shock, such as sudden floods or forest fires. Impacts may be either negative or positive. For example, agriculture may become more productive or tourism may flourish in areas experiencing higher temperatures. On a global level, the negative impacts will generally outweigh the economic benefits[5]. Table 2.1 gives an overview of how some important economic sectors may be affected by climate change.

[4] This includes emissions from households, as these are the result of final consumption.
[5] This will of course be very dependant on the specific country and economic activity.

Table 2.1 : Economic impacts for different industries

Agriculture

- Higher temperatures will increase agricultural production in some areas and decrease it in others.
- Changes in the frequency and intensity of extreme weather conditions (droughts, extreme heat, heavy rainfall, storms) will have a negative impact on agricultural production.
- Higher temperatures will enhance the risk of animal diseases affecting livestock.

Forestry

- Climate change may affect the net growth rate of forests.
- Forest fires and storm damage may become more frequent and severe as climate change alters temperatures and aridity, and accelerates tree mortality from insects and disease.
- Extreme weather events will effect timber production and certain ecosystem goods and services.

Fisheries

- Warmer stream temperatures resulting from increased global temperatures reduce (or increase) the amount of habitat that can viably support certain fresh water fish species, such as salmon.
- Fish stocks in the oceans may be affected by changes in temperature, sea currents, biological food chain etc.

Energy supply

- Droughts or changed precipitation patterns may cause a reduction (or increase) in hydropower production.
- Increased surface water temperatures or reduced runoff may reduce the cooling water availability for electricity production.
- Higher temperatures during summer months will induce residential consumers but also businesses to use more electricity for air conditioning.
- Higher temperatures during climate-related heat waves will increase the amount of energy lost during electricity-transmission lines.

Water supply

- Droughts or changed precipitation patterns may cause water scarcity.
- Increased water demand due to higher temperatures may put water supply under stress.

Transport

- Inland water transport may be hindered in times of reduced runoff in rivers.
- Transport may be stimulated due to less sea ice or ice in rivers.

Financial sector

- Increases in the frequency of extreme weather conditions may affect the financial sector, in particular the insurance sector through the amount of compulsory payments.

Government

- Rising see levels and increased runoff by rivers will increase the risk of flooding. Damage costs and adaptation costs with regard to shoreline protection and river basin protection will increase.
- Higher temperatures and more extreme weather conditions will cause more damage to infrastructure (roads, waterways, buildings etc.).

Health sector

- Increased temperatures particularly during summertime favour the production of low-altitude ozone, which negatively impacts the health of humans that live in urban areas and creates costs associated with increased rates of morbidity, premature mortality, and lost worker productivity.
- Additional heat waves (days with temperatures consistently above a threshold specific to different geographic areas) are expected to increase mortality rates and medical costs of those already suffering from cardiovascular, cerebrovascular, and respiratory diseases.
- Climate change will make wider areas hospitable to vectors that produce diseases, such as the West Nile virus, encephalitis, and Lyme disease.

Beside industry specific impacts, the economy as a whole may be at risk in certain areas due to an increase in sea level and an increase in runoff by rivers. Coastal zones usually contain large human populations and a high concentration of economic activities. Flooding and extreme storm events may seriously disrupt economic activities and cause loss of produced capital. The same is true for areas adjacent to major river systems which may be subject to flooding when precipitation and runoff increases.

From the list abroad, the economic impacts of climate change can be grouped into three main headings (Bordt and Smith, 2008):

- Impacts on natural capital (water, energy, forests, fisheries, etc.)
- Impacts on produced capital (infrastructure, fixed capital in coastal regions, etc.)
- Impacts on human capital (health of employees, etc.)

Changes in the availability of these types of capital and the productivity with which they can be exploited may affect the structure and output of the economy.

Assessing the impact of climate change faces a fundamental challenge of complexity. The set of mechanisms through which climate may influence economic outcomes, positive or negative is extremely large and difficult to investigate. For example, a decrease in agricultural output or value added may be induced by climate change. However, climate change is only one driver among many that will shape agriculture in future decades. Other factors, such as technological developments, socio-economic factors or other environmental issues could have a similar large impact.

Responses to climate change

There are two general (policy) responses that can be used to address climate change, namely mitigation and adaptation. Mitigation refers to measures that reduce greenhouse gases in an effort to slow down the climate change process. It is a human intervention to reduce the sources or enhance the sinks of greenhouse gasses. Adaptation is adjustment in natural and human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. When it will not be possible to (completely) reverse the ongoing global warming, it will be necessary to take steps to reduce the negative impacts of climate change. Here has been an extensive debate whether mitigation or

adaptation is the best policy response to climate change. The dominant view is that we need both at the same time.

Policy measures with regard to mitigation include the following:

- Carbon taxes, or taxes on the use of fossil energy
- Subsidies for energy saving or renewable energy production
- Tradable emission permits
- Regulations and efficiency standards
- Voluntary agreements between industry and governments
- Technology transfers to developing countries
- Information and education

Policy measures with regard to adaptation include the following:

- Construction of dikes and seawalls to protect against floods and hurricanes
- Subsidies to promote a shift in agriculture
- Improve disaster en crisis management
- Promote climate-proof building techniques
- Education plans

All these policy measures will directly or indirectly influence the economy. Policy measures may lead to extra costs for companies and households which may reduce economic growth. On the other hand, innovation in new technologies and new investments in infrastructure and knowledge may create new opportunities for economic development.

3. Climate change in SEEA

Satellite accounts offer an extension to the central framework of the national accounts by providing a detailed representation of a specific area. The SEEA is a satellite system of the System of National accounts in the area of the environment. It brings together economic and environmental information in a comprehensive framework to measure the contribution of the environment to the economy and the impact of the economy on the environment. Specific accounts cover natural resources such as oil and gas, material flows, air emissions, water, waste, and environmental expenditure. The environmental accounts provide a tool to analyse to what extent our current production and consumption patterns are depleting natural resources or are polluting the environment. In addition, the system includes

information about policy measures such as environmentally related taxes or subsidies. The environmental accounts are internationally comparable through common frameworks, concepts and methods.

Climate change as an environmental issue is not specifically addressed in SEEA. Accounts that are relevant to climate change and useful applications can be found scattered in the different chapters. This is because SEEA is a statistical framework that can be used to describe several environmental issues. The system does not focus on one specific environmental issue. It is scheduled that in part III of the revised SEEA, the application part of the handbook, climate change will get a more prominent description (Harris, 2008). In the following section the parts in SEEA relevant for climate change will be identified and discussed.

3.1 Physical flow and hybrid accounts

The physical flow accounts in the SEEA 2003 describe flows within the economy as well as those between the economy and the natural environment. Four different types of flows are distinguished: natural resources, eco-system inputs, products and residuals. The recommended classifications underlying the physical flow accounts are tuned to the various types of physical supply and use tables such as those for the subsystems on energy, water and materials. Hybrid accounts show coherent physical and monetary data within one table. Several of these flow and hybrid accounts contain information that is very relevant to climate change related issues.

Air emission accounts

The air emission accounts show the origin and destination of several air pollutants, among which the greenhouse gasses (CO_2, CH_3, N_2O, F-gasses) (SEEA2003, par. 4.78-4.98; Eurostat, 2009). The emissions from the different greenhouse gasses can be aggregated according to their global warming potential. Accordingly, the total aggregated impact potential expressed in CO_2-equivalents can be determined. In the origin table the emissions are allocated to the different industries, households and other sources (waste dump sites). The destination table for greenhouse gasses is not relevant as climate change is a global environmental problem, and thus exactly where the emissions are produced (inland or abroad) is not relevant[6]. The air emission accounts are based on the residence principle, and, accordingly, the emission totals differ from those for the Kyoto protocol. Bridge tables illustrate the difference between the different concepts.

[6] When subsoil CO_2 storage will be implemented this can be shown in the destination table.

The air emission accounts in combination with the national accounts can be used for all kind of analyses (e.g. Eurostat, 2009). With regards to the analytical range of air emissions accounts a general distinction can be made between a *production perspective* and a *consumption perspective*. The first considers all the direct air emissions arising from national production and distinguishes and compares the environmental performance of different industries. The air emission accounts provide essential information for the understanding the sources of greenhouse gasses in order to assess the pressure of the economy on climate change. Emission intensities or decoupling graphs give an indication how the economy and different industries are performing with regard to the production of greenhouse gasses. Decomposition analyses show the underlying economic effects causing a certain change in greenhouse gas emissions over time. The effect of globalisation on the emission of greenhouse gasses, i.e. emissions caused by international transport can be obtained from the accounts.

The second, the consumption approach, considers the direct and indirect air emissions arising along the international production chains of all products consumed nationally, and compares the air emissions caused by the final use of different product groups or broadly compares across the different categories of final use such as consumption, investments and exports. The emission trade balance shows how much greenhouse gas emissions are associated with the import and export of goods and services and can be used to calculate total greenhouse gas emissions related to domestic consumption.

Energy flow accounts

The energy flow accounts represent a consistent framework in which energy data, both in monetary and physical terms, have been integrated into the national accounting framework. The supply table shows how much energy products are produced or extracted within a country and how much energy products are imported from abroad. The use table shows the total intermediate use, the final use by households and the exports of energy products. The main characteristic of the energy flow accounts is that they are, like all other environmental accounts, compiled according to the definitions of the National Accounts. The energy accounts thus provide a complete overview of the supply and use of energy commodities of the economy.

As combustion of fossil fuels is the main cause for greenhouse gas emissions, energy statistics are very relevant for climate change. A good insight in the different uses of energy, energy intensity, changes in the energy mix, and energy saving by industries and households will help to analyse the development of this driving force. As with the air emission accounts, all kinds of analyses can be done to estimate the different impacts of policy.

Of particular interest are the energy accounts on *renewable energy*. The supply table shows how much renewable energy (wind, solar, water, biomass, etc.) is produced and by which industry. An important indicator that can be derived from the accounts is the share of renewable energy in the total energy use of the economy. In combination with monetary energy accounts the financial importance can be shown.

Water flow accounts

Physical supply and use tables for water describe water flows within the economy and between the economy and the environment. The accounts follow water from its initial abstraction from the environment by the economy, its supply and use within the economy, to its final discharge back into the environment (SEEAW, par 3.1). Water accounts are particularly relevant in our understanding of the impacts of climate change with respect to changes in water availability (Bain, 2008). Water flow accounts identify the sources of pressure on water resources and changes therein over time. Hybrid accounts for water describe in monetary terms the supply and use of water related products and services. The linkage between physical and monetary information allows the evaluation of the impact on water resources of changes in the economy, e.g. changes in economic structure, change in interest rates, etc., as well as potential efficiency responses to expected increased scarcity and value of water resources.

Waste accounts

The waste accounts give an overview of the origin and destination of all solid waste generated by economic activities. Some aspects of waste are interesting with regard to climate change. First of all, waste can be incinerated contributing to CO_2 emissions to the atmosphere. Secondly, waste-dump sites (controlled or uncontrolled) release methane emissions. Waste accounts thus provide information on some important sources of greenhouse gasses.

Other physical flow accounts

Beside the flows of materials already covered in the sub-accounts discussed above, the general framework of physical supply and use tables for material also provides some extra information on flows of various other materials relevant for climate change issues. Material flow accounting can be used to compile an overall carbon balance for the economy. Evaluating the flows related to biomass (short cyclic CO_2) versus flows related to fossil fuels may help to identify a transition of an economy based on more “green” raw materials.

3.2 Asset accounts for natural resources

Asset accounts for natural resources describe the stocks and changes in stocks both in physical and monetary terms. The economic importance of these assets is captured through valuation methods. Several of the natural resources within the SEEA asset classification are relevant to climate change issues. As discussed climate change may impact directly (on indirectly) the availability of these natural resources. Therefore, asset accounting can be very useful to quantify these impacts. However, for all these potential impacts it will be difficult to attribute the observed changes in stocks directly to climate change, as they may be influenced by other causes as well (Bordt and Smith, 2008).

Energy resources

Climate change will not directly affect the availability of subsoil resources for oil, gas, or coal. However, the possibility of the economy to exploit them may change due to impacts on infrastructure. This will directly affect the valuation of these assets (Bordt and Smith, 2008).

Also of interest may be the valuation of renewable energy resources (Van Rossum et al., 2009). At present only fossil energy resources are recorded as non produced assets on the National balance sheet in the National accounts. Recording non-renewable energy resources (hydropower, wind, solar) on the national balance sheet will make their relative importance to the economy with respect to their fossil counterparts explicit.

Water resources

Climate change will have a direct impact on water resources worldwide. Areas in which runoff is expected to decline are likely to face a reduction in the value of the services provided by these resources. Asset accounts for water describe the stocks of water at the beginning and end of an accounting period and the change in these stocks due to natural causes (precipitation, evapotranspiration, outflows etc.) and human intervention (abstraction and returns) (SEEAW-chapter 6). The SEEA asset boundary is very broad to include all inland water bodies, namely surface water (rivers, lakes, artificial reservoirs, glaciers, snow and ice), groundwater and soil water. These accounts can thus be used to monitor water resource availability and issues related to water scarcity. Valuation techniques may make the economic importance of these water resources more directly explicit (SEEAW, chapter 8), although the experience in this area is still limited. Asset accounts can also be compiled on the basis of water quality, describing the stock of water of a certain quality in a certain accounting period.

Biological resources

Forests, fisheries and other biological resources yield economic benefits once harvested. All these biological assets will be directly affected by climate change. Asset accounts in physical terms will record the stock levels and the changes in stock. Changes in the economic value will be reflected in the corresponding monetary asset accounts for these resources.

Forests are of particular interest as they are one of the main greenhouse gas source and sink categories in reporting greenhouse gases according to the UN climate convention and the Kyoto protocol (Muukonen, 2008). Of the environmental asset accounts categories in SEEA2003, cultivated and non-cultivated timber resources (EA.141) and wooded land (EA.23) are directly linked to forest categories of the GHG inventory system. The forest asset accounts describe stock levels and changes in stock for timber. These accounts can be amended to record the annual change in carbon stock (changes in living biomass, changes in dead wood and litter, changes in mineral and organic soil). In this way carbon sequestration can be recorded. The scope of SEEA exceeds that of the LUCUCF sector, as the latter only includes managed forests.

Land and ecosystems

Ecosystems provide a wide range of products and services to the economy and the society. As climate change will have a direct impact on these ecosystems, also the goods and services they supply will be under threat. Likewise, climate change may affect the quality and availability of land as an economic resource.

The land and ecosystem accounts, which have been developed by the EEA, provide a tool for understanding the links between the ecosystem goods and services that are vital for human well-being and the underlying processes that generate them (Lange and Weber, 2006; SEEA2003 chapter 8F). The accounts consist of three components: Land cover accounts, land use and ecosystem accounts, and economic accounts. The components are linked by classifications of natural systems, of the economic system (SNA), and by common spatial and temporal references. Land use accounts show the land use by economic activity and can be used to calculate land productivity. The land cover change matrix records the changes in land cover that occur over time.

Land cover accounts have well been developed and implemented. However, the framework for land use and ecosystem accounts has been developed but only partially implemented, and the connection between ecosystems and the economic system is still in an exploratory phase. Although methods for the valuation of ecosystems are improving, it is not yet possible to calculate the wide range of ecosystem products and services.

3.3 Accounts for environment-related transactions

The accounts for environment-related transactions make more explicit the elements of the existing SNA which are relevant to the good management of the environment, both in the area of environmental protection as in the area of resource management. These economic accounts cover a broad area including EPEA (environmental protection expenditure accounts) and accounts for environmental taxes and subsidies, emission permits and the environmental goods and services sector.

Environmental protection expenditure

Environmental protection expenditure accounts aim at describing the measures and the related expenditures carried out to protect the environment from a qualitative prospective, i.e. against pollution and degradation. Environmental protection expenditure is defined as all costs related to activities and purchased products that *primarily* serve the purpose of prevention, reduction and elimination of any degradation of the environment caused by economic activities. Thus, activities, while beneficial to the environment, that primarily satisfy economic purposes, are excluded[7]. Also activities that primarily satisfy technical needs or health or safety standards and risk management are excluded. The environmental protection expenditure accounts can be used to analyse the effects of policy measures on environmental activities and to analyse future scenarios.

Expenditure related to reducing greenhouse gas emissions are part of the environmental expenditure accounts. However, there are two important problems:

1. Environmental protection expenditure related to reducing greenhouse gas emissions are part of CEPA 01 'protection of ambient air and climate'. So, no distinction is made between expenditure related to air pollution and climate change[8].
2. A large part expenditure related to energy saving are also undertaken for cost saving reasons and become profitable within three years time. As discussed above, these are excluded from the environmental protection expenditure accounts.

[7] In environmental protection expenditure accounts all environmental investments that become profitable within three years time are excluded.
[8] On a lower level, CEPA distinguishes prevention of pollution for the protection of climate and the ozone layer (CEPA1.1.2) and treatment of exhaust gasses for the protection of

For these reasons, environmental protection expenditure accounts do not provide a good picture of monitoring or mitigation measures.

Resource use and management expenditure

Accounts for resource use and management expenditure are still under development. Recently, a new classification system (CREMA) for environmental resource expenditure has been developed by ISTAT, which will be included in the new SEEA (ISTAT, 2009). Definitions and demarcation are presently undertaken in a new Eurostat taskforce.

With regard to climate change resource use and management expenditure include a) the reduction of the use of non-renewable energy sources through the minimisation of heat and energy losses and through energy saving, and b) the production of energy from renewable sources are of interest. When implemented these categories will be excluded from CEPA.

Environmental taxes

An environmental tax is 'a tax whose tax base is a physical unit (or a proxy of it) of something that has a proven negative impact on the environment' (OECD/EC definition). Environmental taxes relevant for reducing greenhouse gas emissions are taxes with a tax base on energy products or transport.

Energy taxes include taxes on energy products used for both transport and stationary purposes. The most important energy products for transport purposes are petrol and diesel oil. Energy products for stationary use include fuel oils, natural gas, coal and electricity. With regard to electricity, only taxes on electricity produced by combustion of fossil fuels should be taken into accounts. When a significant part of the electricity is produced by renewable sources or nuclear power, this may cause a problem. Particularly relevant are of course CO_2-taxes, which are included under energy taxes rather than under pollution taxes. If they are identifiable, CO_2-taxes are reported as a separate category next to energy taxes.

Transport taxes mainly include taxes related to the ownership and use of motor vehicles. Taxes on other transport equipment (e.g. planes), and related transport services (e.g. duty on charter or scheduled flights) are also included here, when they conform to the general definition of environmental taxes. Taxes on petrol, diesel oil and other transport fuels are included under energy taxes.

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climate and the ozone layer (CEPA1.2.2), but still climate change is not separated from ozone layer depletion.

Environmental subsidies

Accounts for environmental transfers (subsidies) provide an overview of all environmentally motivated subsidies, classified by environmental domain (CEPA) and the receivers of the subsidies (ISIC, households). The concepts, definitions and classifications for environmental subsidies are presently being developed in an Eurostat taskforce. Accounts for environmental subsidies will be part of the revised SEEA.

There are generally three categories that are interesting with regard to climate change, namely 1) subsidies related to energy saving, 2) subsidies for the production of renewable energy, and 3) other subsidies with regard to climate change, which are subsidies that aim to reduce the other greenhouse gasses (methane and N_2O) and innovation subsidies. To be useful to analyse climate change, these categories should be individually identified within the group of environmental subsidies.

Emission trading

Emission trading (ETS) is a relative new policy instrument for governments to support mitigation strategies. In 2005 emission trading for CO_2 was introduced for Europe. The System of National Accounts 1993 (SNA) and the Handbook on National Accounting on Integrated Environmental and Economic Accounting 2003 (SEEA) treat emission permits as assets.

The current revision of the system of national accounts has taken the emission trading schemes into account. It was concluded that the emission permits should be recorded as taxes. Also in the revised SEEA, emission permits will be discussed in depth and included in the standard (Olsen, 2008). Emission permits can be accounted for both in physical and monetary balances. These balances show the opening stock, changes in stock (permits allocates, purchased, sold, surrendered, closing stock. For politicians and other decision-makers, information on the CO_2 permits is very policy relevant. If described within the Environmental-Economic Accounting framework, the CO_2 emission permits accounts would be able to answer a number of questions, such as who is trading, the relationship between the emissions of CO_2, energy use and the emission permits, etc.

Environmental goods and services sector

The Environmental goods and services sector consists of an heterogeneous set of producers of technologies, goods and services that measure, control, restore, prevent, minimise, research and sensitize to resource depletion and environmental damages to air, water, and soil, as well as problems related to waste, noise, biodiversity and

landscapes. The Environmental goods and services sector is distributed over many different ISIC classes. Particularly relevant with regard to climate change are companies specialised in producing energy saving equipment and producers of renewable energy. In addition there are companies and parts of the government that work on climate change issues such as mitigation policies and related water management. The Environmental goods and services sector will help to identify the economic opportunities created by the climate change with regard to production, value added, and labour created.

3.4 Other accounts relevant to climate change

The SEEA is one of the satellite accounts that have been developed within the framework of national accounts. Other extensions have been compiled in the area of tourism, agriculture and health (SNA2008).

Regional accounts

Regional accounts provide economic information according to the national accounts concepts on a sub national level, for example provinces, state or county. Beside purely administrative regions, it is also possible to look at other regional divisions such as river basins or coastal areas. For example, regional accounts can be compiled for coastal areas that run the risk of flooding, which are very important for assessing the economic importance in relation to potential impacts of climate change.

Tourism accounts

The tourism satellite account (*TSA*) provides macroeconomic aggregates that describe the size and the economic contribution of tourism. The TSA is a satellite account of the System of National Accounts and can therefore easily be linked to various environmental accounts. Accordingly, the TSA can be used as a basis from which the effects of climate change on tourism can be measured, and, on the other hand, function as a measurement tool for pressures on climate change originating from tourism (WTO, 2007). The national accounts basis facilitates modelling possibilities of the results. Several studies have taken place to link the TSA with different parts of the environmental accounts and environmental pressure measurement methodologies.

Agricultural accounts

The economic accounts for agriculture (EAA) are a satellite account providing complementary information and concepts adapted to the particular nature of the agricultural industries (Eurostat, 1997). The main purpose of the Economic

Accounts for Agriculture and Forestry is to analyse the production process and primary income generated by it. The accounts consist of current accounts (production accounts, generation of income account, entrepreneurial income account) and accumulation account (capital account). The economic accounts for agriculture do not contain physical information on, for example, the total physical production (in kg) or the number of livestock. This information can be obtained from the material flow accounts (MFA) and other statistics (environmental and agricultural) (EFTEC, 2004). As agriculture is an important sector, both as a source of greenhouse gasses and as it will be particularly susceptible to the effects of climate change, the EAA, supplemented with physical data from the MFA, will provide useful data source in this area.

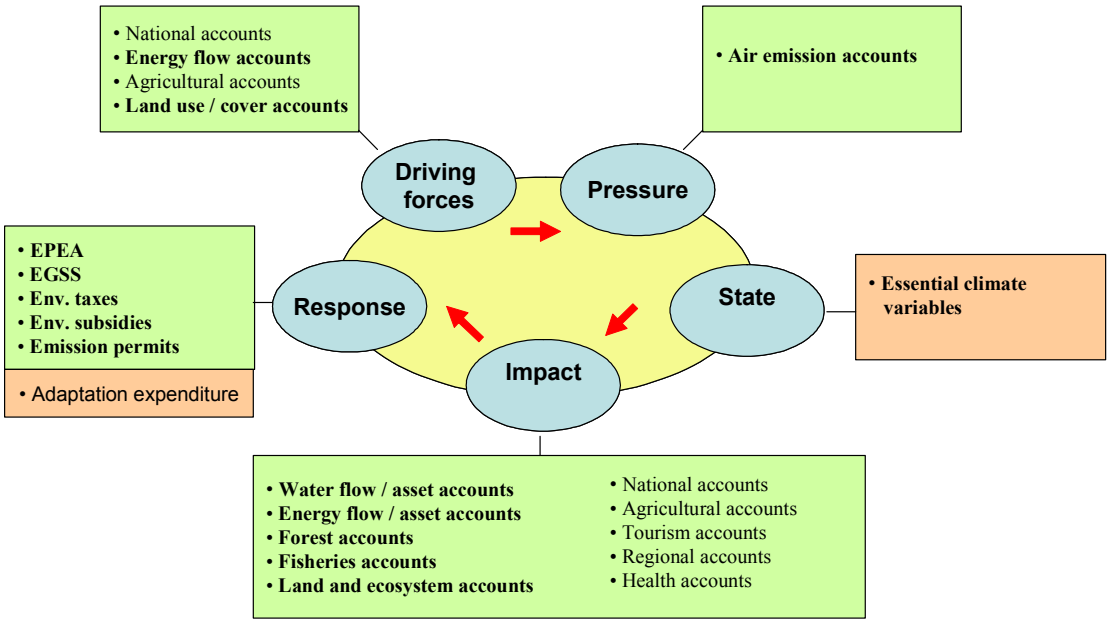
Health accounts

The health care industry is of significant size and importance in many countries in terms of the number of people employed and the level of turnover. The *System of Health Accounts (SHA)* provides a framework for analysing health care systems from an economic point of view, consistent with national accounting rules. There are four categories of information provided: a functional classification of health care, an analysis of health care provider units, information on expenditure on health care and information about the funding of health care. Health accounts provide a potential important information source to analyse the impact of climate change on the health sector.

4. Synthesis: integrating the parts of SEEA into the DPSIR model

All the different accounts identified in the previous paragraph can now be linked to the DPSIR model (Figure 4.1).

Figure 4.1: Integrating the accounts into the DPSIR model



With the exception of state, data from the environmental accounts, national accounts, and other satellite accounts cover all parts of the DPSIR model. The (economic) driving forces are well described by the national accounts, complemented by information from the energy accounts, agricultural accounts and land cover/use accounts. The pressure with regard to the GHG emissions related to economic activities are fully described by the air emission accounts. The SNA also provides a coherent dataset that can be used to assess the potential impacts of climate change. Environmental accounts are particularly suitable to record changes in natural resources. National accounts and regional accounts can describe the impact on produced capital. Furthermore, specific satellite accounts for tourism, agriculture and health can be helpful to determine the economic effects for these sectors, which will be particularly vulnerable with regard to climate change. Finally, information on all important policy measures with regard to mitigation of climate change, including the impact of these measures on companies and households, can be found in the accounts for environment-related transactions.

There are, however, also some important subjects that are currently missing. The first is related to adaptation expenditure. As discussed, this kind of expenditures fall

outside the scope of the EPEA and the resource expenditure accounts. Clear definitions on adaptation expenditure are lacking. Information on adaptation expenditure by the government may be obtained from government budgets. For example, the costs involved for coastal protection should be listed here. Also special programs related to adaptation to climate change (o.a. research) are to be found. Adaptation expenditure for companies and households will be harder to determine. With the proper definitions and classifications, this kind of expenditures can be added to the framework of environmental accounting. Clearly, this subject first needs conceptual thinking before statistics may be compiled.

A second area lacking from the accounting framework is information on the state of the environment. However, information on the essential climate variables (for example temperatures, precipitation rates, sea level etc.) can easily be added to the framework, as there are no problems with regard to classifications, definitions and concepts.

5. Possible set-up of the Dutch climate change accounts

5.1 The Netherlands and climate change

As discussed above, climate change accounts may contain a wide range of different subjects. When compiled on a national scale, the possible set up of climate change accounts will be very dependent on the nature of the country. On the drivers and pressure side the structure of the economy may differ. For example, the size and character of agriculture or the way electricity is produced may be very different. However, the general set up will be more or less the same. Particularly the expected impacts of climate change on the economy will vary regionally. Therefore, especially in this area the most relevant accounts may vary from country to country.

Several climate change scenarios have been developed to predict the possible extent of climate change for the Netherlands (KNMI, 2006). The scenario's show that there is a 80 percent chance that the mean temperature increase will be between 0,9 and 2,3 C°. The temperature increase for the Netherlands will be above the world average. Summers will become more dry. The expected sea level rise is between 15 and 35 cm in 2050.

The following list of potential economic impacts caused by climate change for the Netherlands is based on a study which investigated the potential impacts of climate change in 2050 (VROM, 2007):

Agriculture

- Flooding due to excessive rain may cause problems in winter, whereas water shortages are likely to occur during summer.
- A lengthening of the grow season may positively affect the agricultural output.
- Groundwater resources may decrease in volume or become brackish.

Energy

- The warming of surface waters during summer may cause problems for using it for cooling water by energy producers.

Coastal and river defence

- Due to rising sea levels there is a higher probability of coastal erosion and coastal flooding.
- High river discharge may cause flooding.
- Higher water levels in the IJsselmeer area will also enhance the possibility of flooding.

Transportation

- Low river levels in summer may hamper inland shipping.
- Extreme weather conditions may obstruct road, water or air transport.

Infrastructure

- Extreme weather conditions may damage buildings, oil platforms, high tension networks, roads, bridges etc.

Health

- Increase of diseases like Lyme and allergies.
- Decrease of air quality (smog in summer).

Tourism

- Decrease in water quality may deteriorate swimming conditions.
- Overall higher temperatures may benefit inland tourism.

A close look at this list makes clear that most climate change impacts have to do with water. A low-lying country as the Netherlands, for a significant part situated below sea level, is particularly vulnerable to the expected increase in sea level. In addition, the Netherlands are a delta system where three major rivers (Rhine, Meuse, Scheldt) come together and flow into the sea. Enhanced runoff may threaten a large part of the country. Finally, some important economic sectors, namely agriculture, the energy sector, water supply, inland shipping and tourism may be impacted by reduced water availability, deteriorated water quality, or irregular precipitation rates.

5.2 Climate change accounts in the Netherlands: a proposal

Table 5.1 provides an overview of the accounts relevant for climate change issues that are available in the Netherlands, under development, or not available. Also the specific relevance of a particular account for the Netherlands is indicated.

Table 5.1: Accounts relevant for climate change issues in the Netherlands (2009)

		Available	Under development	Not available	Relevence
Drivers	National accounts	X			R
	Energy accounts	X			R
	Land cover / land use accounts[1]	X		X	R
Pressure	Air emission accounts	X			R
Impacts	National accounts	X			R
	Regional accounts		X		R
	Tourism accounts	X			R
	Agricultural accounts	X			R
	Health accounts			X	R
	Energy asset accounts (subsoil)	X			LR
	Energy asset accounts (renewable)		X		R
	Forest accounts			X	LR
	Fisheries accounts			X	LR
	Land cover / land use accounts[1]	X			R
	Ecosystem accounts			X	R
Response	Mitigation expenditure	X		X	R
	Adaptation expenditure			X	R
	EGSS		X		R
	Environmental taxes	X			R
	Environmental subsidies		X		R
	Environmental permits		X		R

[1] Land cover accounts are available, land use accounts have not yet been developed.

The Dutch environmental accounts already contain several sub-accounts with information relevant to climate change, such as air emission accounts, energy accounts, environmental taxes, etc. Other accounts are presently under development such as the environmental goods and service sector, environmental subsides, emission permits etc. The relevance of accounts for fisheries and forests for the Netherlands is limited, as the available stocks of these resources are small and the impact of climate change will be hard to determine. Important areas that are at this moment missing are accounts for adaptation expenditure, land use accounts and ecosystem accounts. As discussed in paragraph 4, these accounts are not very well developed in the statistical world yet.

6. Conclusion and recommendations

The System of Integrated Economic Environmental accounts, together with the System of National Accounts and related satellite accounts, has the potential to bring together in one consistent analytical framework all relevant information with regard to the relationships between the economy and climate change, that can be used for climate change assessment, policy and decision making. The accounts ensure coherence in data, as they are all part of one accounting framework based on the same concepts, definitions and classifications.

Accordingly, climate change accounts can be defined as a subset of the environmental accounts that contain relevant information to climate change issues. The accounts are very useful to assess both the driving forces and the pressures, but also the impacts and responses with regard to the interrelationships between the economy and climate change. Information on the state of the environment, which are not part of the accounts, can easily be added from other data sources.

Although many important topics relevant to climate change are already covered in the accounting framework, we have identified some issues that need further development:

- Expenditure related to climate change mitigation is not well described within in the EPEA. The CEPA code for climate change is at this moment at a three digit level. Also, expenditure concerned with energy saving is not included.
- Adaptation expenditure is not part of EPEA. Further research is needed into the concepts, definitions and classifications to add this subject to the accounting framework.
- The development of land and ecosystem accounts is still in a preliminary phase. As these accounts are very relevant to climate change further research to implementation or a partial implementation is worthwhile.
- The social dimension is as yet not part of the framework, but these issues could potentially be added to the system. Further research is needed here.

In the Netherlands, the environmental accounts already include many sub-accounts that bear relevance to climate change (2009). These sub-accounts could be presented together, either in a computer database, website or publication, to constitute the Dutch climate change accounts.

With regard to the further development of climate change accounts in the Netherlands the following recommendations can be made:

- *Water accounts.* Potential impacts in the area of water will probably be very important in the near future. The Dutch water accounts are as yet incomplete. In the physical supply and use tables important flows from the economy to the environment (waste water, cooling water) are not accounted for. In addition, the complete water balance for the Netherlands, both on a national and a regional scale, is not available. Also asset accounts for ground- and surface water have never been compiled. It is therefore recommended to a) compile a complete national water balance (stocks and flows) for the Netherlands and b) research the possibilities for a further disaggregation of this water balance to water basin, water board, or residential area, as this is the level for which policymakers, the water boards and other stakeholders need information.
- *Regional accounts*. The most serious threat facing the Netherlands in the future is the risk of floods due to sea level rise and the enhanced runoff by rivers. It is therefore important to know which areas are endangered and what the economic consequences are when these areas are flooded. For this regional accounts can be compiled. It is possible to make these accounts for production, value added and labour. It should be investigated if it is possible to make regional accounts for produced capital.
- *Adaptation expenditure*. As a first step, the adaptation expenditure of the government could be compiled. These expenditures can be found in the budget lines. In the Netherlands, expenditures related to the construction and maintenance of seawall and dykes, and related monitoring are very important. As a second step a feasibility study could be done to compile adaptation expenditure for households and industries.
- *Land and ecosystem accounts.* As a first step, land use accounts could be compiled. Ecosystem accounts are as yet a bridge too far and it seems prudent to await future developments in this area.

Acknowledgements – The author wishes to thank Roel Delahaye, Cor Graveland, Maarten van Rossum, Isabel van Geloof, Bram Edens and Hendrik Jan Dijkerman for their useful comments.

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