Draft recommendations on climate change related statistics

Prepared by the
Conference of European Statisticians'
Task Force on Climate Change Related Statistics

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EXECUTIVE SUMMARY

This report presents recommendations improving the statistics related to climate change collected by national statistical systems and enhancing their utility for the compilation of greenhouse gas inventories. The recommendations have been developed by the Task Force on Climate Change Related Statistics which the Bureau of the Conference of European Statisticians (CES) established in November 2011. The report primarily addresses data that are already collected by statistical offices and can support analysis or research related to climate change. The report does not focus on scientific or meteorological data on changes in weather and climate as the measurement of these is usually not the task of the statistical system.

In June 2012, the Rio+20 Conference on Sustainable Development emphasized climate change as an immediate and urgent global priority. This has also increased the pressure to provide new information to support analysis of climate change and improve the currently available statistics. To identify data gaps, the Task Force organised an expert meeting to explore user needs and analysed the results of a survey of national statistical offices (NSOs). The Task Force carried out interviews of users of climate information such as the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC), research agencies, non-governmental organizations and universities.

The Task Force defines climate change related statistics as *environmental, social and economic data that measure the human causes of climate change, the impacts of climate change on human and natural systems, the efforts of humans to avoid the consequences as well as their efforts to adapt to these consequences*. To narrow down the focus of work for official statistics, the report suggests a pragmatic approach with concrete recommendations in areas where the involvement of official statisticians is most important.

The Task Force noted that climate change data are scattered across a variety of organisations and are largely unstructured. The wide range of official environmental, social and economic statistics could be better utilized for climate change analysis.

The report recommends that NSOs should work more closely with greenhouse gas inventory producers to see that their data fit the purposes of emission inventories as the inventories require a considerable amount of statistical data. In this regard, NSOs should be recognized as formal entities in the national greenhouse gas inventory systems in all countries. This could be done simply by explicitly noting the role of the NSO in the inventory documentation submitted to the UNFCCC or more formally via a Memorandum of Understanding between the NSO and the national entity responsible for the inventory.

National governments have for many years published information on greenhouse gas emissions through a well-established collection and reporting process. Information on other aspects of climate change is less well developed even though several statistical offices have started to work in this direction.

NSOs should start improving data relevant for climate change gradually and based on their key competencies. First, the existing climate change information should be better organised, for example the NSOs' communication channels would provide an efficient means of disseminating these statistics. As a second step, the usefulness of the existing environmental, social and economic statistics for climate change analysis should be improved by reviewing the existing data collection systems. In this context, the Task Force underlines the importance of linking and geo-referencing social, economic and environmental data and improving their coherence to maximize the potential for climate analysis. Third, new statistics, for example on the underlying driving forces, social and economic impacts of climate change, mitigation efforts and vulnerability and adaptation are needed.

The global nature of climate change calls for wider cooperation among the involved organizations to better respond to the growing information needs. NSOs should also be consulted on emission inventory methodology development. They could add value by assessing data availability and feasibility of requirements related to the Kyoto protocol, and by preparing themselves for new data requirements. The international statistical community should also contribute to the international climate accords and the global greenhouse gas inventory system.

The Task Force realizes that the above will challenge the infrastructure of statistical offices and may require reviewing of classification systems, registers, definitions and data contents of surveys as well as finding new ways to deal with confidentiality to balance with the need for detailed data. Statisticians will gradually require new kinds of expertise and ability to adopt new methodologies for producing climate change related statistics. In the longer run, organizational changes may be needed to support the production of these statistics that cut across the statistical system.

These are the first recommendations developed to help NSOs improve climate change related statistics, and enhance their support to greenhouse gas inventories. Further international work will be needed to provide guidelines on how to take into account the needs of climate change analysis and greenhouse gas inventory compilers in official statistics. The report also identifies some issues to be included in the future research agenda on climate change related statistics.

LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
CES	Conference of European Statisticians
CIS	Commonwealth of Independent States
CO_2	Carbon dioxide
COP	Conference of the Parties
CPC	Central Product Classification
CRF	Common Reporting Format
CSA	Classification of Statistical Activities
DECC	Department of Energy and Climate Change of the United Kingdom
DG-CLIMA	Directorate-General on Climate Action of the European Commission
DPSIR	Driving forces – Pressure – State – Impacts – Response
ECLAC	Economic Commission for Latin America and the Caribbean
EU	European Union
EEA	European Environment Agency
EGS	Ecological Goods and Services
ETS	European Trading System
FDES	Framework for the Development of Environment Statistics
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gross National Income
GVA	Gross Value Added
IEA	International Energy Agency
IMA	Impact, Mitigation and Adaptation
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification of all economic activities
ITL	International Transactions Log
LULUCF	Land Use, Land-Use Change and Forestry
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne / Statistical classification of economic activities in the European Community
NASA	National Aeronautics and Space Administration of the United States
NOAA	National Oceanic and Atmospheric Administration of the United States
NSO	National Statistical Office

NSS	National Statistical System
OECD	Organisation for Economic Co-operation and Development
QA/QC	Quality Assurance/Quality Control
SEEA	System of Environmental-Economic Accounting
SIEC	Standard International Energy Product Classification
SNA	System of National Accounts
SNAP97	Selected Nomenclature for Air Pollution
UNCEEA	United Nations Committee of Experts on Environmental-Economic Accounting
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSC	United Nations Statistical Commission
UNSD	United Nations Statistics Division (in New York, secretariat to UNSC)
WHO	World Health Organization
WMO	World Meteorological Organization

INTRODUCTION

This report presents recommendations to national statistical systems for improving climate change related statistics, and enhancing their support to greenhouse gas inventories. While this report is aimed primarily at statisticians, it may also serve as a tool for discussions with other producers of climate change related statistics and greenhouse gas inventories.

The interim recommendations were discussed at the Conference of European Statisticians (CES) plenary session in 2013 The Conference supported the work and the findings. The final report is planned to be circulated for wide consultation in early 2014 and submitted to the CES for adoption in April 2014.

The recommendations have been developed by a Task Force on climate change related statistics, set up by the CES Bureau in November 2011. The Task Force consists of experts from the statistical offices of Canada (Chair), Finland, Italy, Mexico, Norway, Qatar and the United Kingdom, as well as the European Environment Agency (EEA), Eurostat, the Directorate-General on Climate Action of the European Commission (DG-CLIMA) and UNECE who provided secretariat support for the Task Force. The following experts worked in the Task Force: Robert Smith (Canada, Chair), Leo Kolttola (Finland, Vice Chair), Martin Adams (EEA), Enrique de Alba (Mexico), Julio Cabeca (Eurostat), Helen Champion (the United Kingdom), Ricardo Fernandez (EEA), Angela Ferruzza (Italy), Julie Hass (Norway), Jesarela Lopez (Mexico), Tiina Luige (UNECE), John Mackintosh (the United Kingdom), Michael Nagy (Qatar), Brian Newson (Eurostat), Rolando Ocampo (Mexico), Adriana Oropeza (Mexico), Anu Peltola (UNECE), Velina Pendolovska (DG-CLIMA), Giovanna Tagliacozzo (Italy), Stefano Tersigni (Italy) and Angelica Tudini (Italy).

This work was an initiative of Heads of national statistical offices of CES member countries (Europe, Central Asia, Caucasus, North America, member countries of Organisation for Economic Co-operation and Development (OECD) and several other countries, including South Africa, Brazil, Mexico and China who participate actively in the work). It is a step towards taking the data needs related to climate change into account in national statistical systems, and improving the contribution of official statistics to analysing climate change related phenomena.

The United Nations Statistical Commission (UNSC) carried out a programme review on climate change and official statistics in 2009. It was based on a paper by the Australian Bureau of Statistics and the outcome of the two Conferences on this topic held in 2008. As an outcome of the review, the UNSC recognised the role of official statistics in closing the data gaps related to climate change, and emphasised the need for better understanding of the data requirements of stakeholders.

In view of these developments, the CES Bureau decided in 2011 to take stock of the current state of work on climate change related statistics in the national statistical offices (NSOs), and asked UNECE to conduct a survey among member countries of the UNECE and the OECD. The survey was carried out with the support of the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) and the United Nations Statistical Division (UNSD) in New York. The purpose was to find out the extent to which the NSOs are involved in producing climate change related statistics and to identify issues of common concern for further work at international level. The survey covered 69 countries reaching beyond UNECE region, and 48 countries[1] replied. Out of them, 37 reported involvement in work related to greenhouse gas inventories and 18 compiled other

[1] Armenia, Australia, Austria, Azerbaijan, Belarus, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Hungary, Ireland, Israel, Italy, the Republic of Korea, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Mexico, Moldova, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom and United States.

statistics related to climate change. Survey respondents called for international work to consider how the data available in the statistical systems could be made more useful for the purposes of climate change analysis and policy making.

Analysing climate change across all its dimensions requires linking climate information produced outside of statistical offices with official statistics on the environment, society and economy. While the survey provided evidence that such linkages are already being made, it showed that there is clearly room for improvement.

Most statistical offices currently provide basic data on economic activities for the compilation of greenhouse gas inventories. These include data on energy, industry, agriculture, forestry, transport, international trade, land use and land cover, wastewater and waste. About one quarter of statistical offices take part in the inventory calculations in addition to provision of data.

To identify practical steps to support future development of climate change related statistics to meet user needs, and enhance the role of official statistics in greenhouse gas inventories, the CES Bureau established the Task Force on climate change related statistics in November 2011 (Terms of Reference for the Task Force are provided in Annex 1). The Task Force was asked to start their work by assessing the gap between user needs and available statistics, and defining the scope of climate change related statistics. The Task Force collaborated with other bodies involved in related international work, including the United Nations Framework Convention on Climate Change (UNFCCC), the Intergovernmental Panel on Climate Change (IPCC), Eurostat, EEA and the United Nations Statistics Division (UNSD). Regular progress reports were submitted to UNCEEA.

The Task Force aimed to identify areas where improvements are most needed and where NSOs can best contribute with concrete actions. The Task Force has paid special attention to making existing statistics more easily available to users and to identifying the highest priority statistical gaps that must be filled. The work focused on six research topics:

1. Defining the scope of "climate change related statistics" and testing different frameworks and models for this purpose;
2. Analysing user needs for climate change related statistics in both the policy and scientific domains to determine where the most pressing needs exist. This was done by conducting stakeholder interviews[2] and by carrying out desk studies on the data needs for emission inventories and climate policies;
3. Reviewing existing statistics of relevance to climate change and comparing those against the needs. The results of the survey of statistical offices was analysed to identify existing statistics and gaps;
4. Analysing the relationships between NSOs and agencies responsible for greenhouse gas inventories to find opportunities for strengthening their cooperation;
5. Reviewing the statistical infrastructure, such as standards, classifications and methods, used to report on climate change related statistics. The Task Force examined the existing infrastructure in NSOs in order to identify gaps and recommend priorities for improving this infrastructure;
6. Identifying practical steps and priorities for future development of climate change related statistics so that they would better meet user needs.

[2] In total, 11 organizations were interviewed about their views on using official statistics in climate change analysis and how statistical offices could improve their contribution: IPCC, UNFCCC, World Health Organization (WHO), World Meteorological Organization (WMO), DG-CLIMA and researchers and NGOs, such as the University of Bologna, Fondazione Eni Enrico Mattei (FEEM), the Finnish Environment Institute, the Carbon Brief and the World Wildlife Fund.

The Task Force organized an expert meeting on climate change related statistics[3] for producers and users on 19-20 November 2012 in Geneva. The meeting explored user needs for climate change related statistics and took stock of what statistical offices are doing in the area. It also discussed the definition of the scope of climate change related statistics. The conclusions of the meeting provided valuable input to the Task Force's work.

The Task Force organised a second meeting on 8-9 October 2013 to discuss this report and its recommendations. The meeting brought various producers and users of climate change information together in order to take into account their views and expectations with regard to official statistics and climate change.

The Task Force was asked to prepare a report to review the current state of climate change related statistics and the possibilities to develop and streamline the work, with a proposal for:

(a) Developing climate change related statistics for evidence-based climate change policies: concrete steps and priorities for further work;

(b) Harmonising and streamlining the work of NSOs on the greenhouse gas inventories.

This report presents the results of the Task Force's work. Chapter 1 begins by discussing the scope of climate change related statistics the Task Force used in its work. The particular competencies of NSOs in measuring climate change related phenomena are also reviewed.

Chapter 2 focuses on the relationship between national statistics and greenhouse gas (GHG) inventories. The chapter reviews the data required for the compilation of GHG inventories with a focus on the data that can be provided by NSOs. The gaps between the needs of inventory compilers in ideal terms and what NSOs are currently able to provide are discussed. This discussion considers gaps in both the data produced by NSOs and the statistical infrastructure required to produce these statistics.

Chapter 3 focuses on climate change related statistics other than those required for GHG inventories. The chapter considers needs related to climate policies and climate change analysis. As in Chapter 2, the discussion looks at existing statistics, gaps in those statistics and gaps in the statistical infrastructure of NSOs.

The report concludes in Chapter 4 with the Task Force's recommendations for the improvement of climate change related statistics. Priorities for the implementation of these recommendations at the national and international levels are also offered.

[3] The following countries and organizations attended the expert meeting on 19-20 November 2012: Albania, Armenia, Belgium, Canada, Egypt, Finland, France, Georgia, Germany, Ireland, Italy, Japan, Kyrgyzstan, Luxembourg, Mexico, Netherlands, Norway, Poland, Republic of Moldova, Slovakia, Ukraine, United Kingdom, Sweden, Switzerland, DG CLIMA, EEA, Eurostat, International Labour Organization (ILO), UNFCCC, United Nations Industrial Development Organization (UNIDO), World Bank, World Meteorological Organization (WMO), World Health Organization (WHO) and the Carbon Brief.

1 SCOPE OF CLIMATE CHANGE RELATED STATISTICS

1.1 Defining climate change

To define the scope of climate change related statistics, this chapter starts by first defining *change*, *climate* and *climate change*.

Change from a statistical perspective is a difference between two observations – usually between two or more points in time. Measuring change well requires consistent and comparable data collected over long time series.

When defining ***climate***, it is necessary to bear in mind the distinction between weather, which we experience daily, and climate, which reflects expected weather patterns over time:

> *"…the difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time… In short, climate is the description of the long-term pattern of weather in a particular area. Some scientists define climate as the average weather for a particular region and time period, usually taken over 30-years. It's really an average pattern of weather for a particular region…An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with thunderstorms."* [4]

Climate change is defined in the United Nations Framework Convention on Climate Change (UNFCCC)[5] Article 1 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*". In addition, the same article also defines the term *climate system*, which means *"the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions."*

In addition, UNFCCC defines the term *adverse effects* of climate change as *"changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience*[6] *or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare*".

Climate change is a global challenge which requires substantial and diverse information. As described by NASA, climate change

> "*will affect people around the world. Rising global temperatures are expected to raise sea levels, and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It could also affect human health, animals, and many types of ecosystems. Deserts may expand into existing rangelands, and features of some of our National Parks and National Forests may be permanently altered*." [7]

Key elements in these definitions are: the human-induced causes of climate change (notwithstanding other natural causes), the fact that the climate is a system comprising several components (atmosphere, hydrosphere, etc.) and their interactions, and the consideration that

[4] Source: www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

[5] Article 1 of the Full text of the Convention: http://unfccc.int/essential_background/convention/background/items/1349.php

[6] IPCC defines resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change."

[7] Source: www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

climate change ultimately affects both the natural environment and the socio-economic aspects of life.

The main *cause* of human-induced climate change cited in the definition is the release of greenhouse gases in the atmosphere. Thus, Article 2 of the UNFCCC, codifying the core objective of the Convention, explicitly addresses this cause:

> "*The ultimate objective of this Convention… is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner*."

Greenhouse gas emissions are released as a result of a number of human activities that underpin development and technological progress, such as, for example, industry, agriculture, transport and the combustion of fossil fuels for electricity production.

1.2 What national statistical offices can contribute to measuring climate change

Competencies

Official statistics[8] have a lot of competencies that are important in relation to climate change. Official statistics and national statistical systems[9] adhere to international principles[10] that bring a number of important attributes to the discourse on climate change. Given the sometimes controversial nature of this discourse, professional independence is one such attribute. Other attributes include a commitment to well-defined quality standards, the use of sound and transparent methodologies, a focus on publishing data in long and consistent time series and a commitment to data accessibility. Official statistics are an important source of reliable information because of the strict conditions and quality criteria under which they are produced.

The main focus of national statistical systems is on human systems and on how they interact with natural systems. NSOs measure the activities of enterprises, individuals, households, institutional and government sectors and regions. Therefore, environmental data that are related to industries and households – as well as climate change – can be covered by NSOs. Official statistics include a link to the geographic region, and several statistical offices also record exact locations and co-ordinates through geo-referencing. The spatial dimension is very important in the context of climate change.

Research studies often provide a picture of a particular issue at a particular point in time. Such studies are, of course, essential in understanding the issue in question and how it might be addressed. But they are not necessarily helpful in understanding how it evolves over time. This is

[8] *Official statistics* comprise any statistical activity carried out within a national statistical system, or under the statistical programme of an intergovernmental organization (definition from Statistical Data and Metadata eXchange 2009: www.sdmx.org/). They are by definition compiled in accordance with the Fundamental Principles for Official Statistics (unstats.un.org/unsd/methods/statorg/FP-English.htm), the European Statistics Code of Practice (epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-32-11-955/EN/KS-32-11-955-EN.PDF) or a similar authoritative international framework ensuring professional standards.

[9] *National statistical systems* comprise the ensemble of statistical organisations and units within a country that jointly collect, process and disseminate official statistics on behalf of national government. They also include the mechanisms of interaction between suppliers, producers, users and other stakeholders. One agency has the coordination role of the national statistical system, usually the national statistical office. In addition, there are international statistical systems that focus on the production of official statistics athe regional or global level. The term "statistical system" used in this report refers generically to the ensemble of all national and international statistical systems.

[10] Namely the Fundamental Principles of Official Statistics and the European Statistics Code of Practice.

where official statistics can be of particular value, given that the development of consistent, comparable time series is a core competence of the statistical system. Official statistics include well-developed methods to adjust data so they are made comparable over time; for example, by accounting for seasonal variation, changes in prices, temperature, etc. When such adjustments are made, the effect of a known source of influence on the variation in the data is eliminated so that only the changes caused by unknown sources of influence and natural variation are left. This type of data treatment can be important when trying to investigate climate change. It is, by definition, an issue that demands evaluation over time and is, therefore, an issue that will benefit from using the long time series available in national statistical systems.

The statistical system also has routines for developing statistics that are internationally comparable – with a global institutional infrastructure to ensure that the definitions, classifications and data collection are harmonized across countries. Furthermore, a core goal of the statistical system is the production of timely statistics, so statistical offices can help in responding to the demand for timely climate change information.

Research has underlined the importance of "*assessing the socio-economic aspects of climate change and implications for sustainable development*"[11]. These are areas where existing data from the statistical system could be linked with climate information to provide a broader and more informed picture of the changes in the future.

Challenges

In spite of the many competencies the statistical system brings to the measurement of climate change, it is true that **existing statistics are not always as useful for climate change analysis as they might be**. Existing official statistics do not, in general, specifically focus on climate change and their content varies a great deal across countries. Thus, if it is to respond to the climate change imperative, the statistical system must make changes to allow it to better respond to the needs for climate change related statistics. This will certainly require changes to the official statistics that are produced and may also require organizational changes within the statistical system.

Statistical systems have a lot of data on different subject-areas. However, they often do not put a great deal of emphasis on **providing cross-cutting data and measuring the interactions between the subject areas**. Identifying and modelling interactions is often the work of economists, academics, government ministries and others working outside of NSOs.

In many countries, NSOs are not responsible for a big part of environmental statistics. For example, state of the environment reports and measures of biodiversity are typically the responsibilities of environment ministries or specialized agencies. One of the challenges of developing climate change related statistics is, therefore, to establish an efficient **coordination and division of work between various national bodies**.

Recently, the focus of official statistics on environmental and climate issues has broadened with many offices offering data on natural resource assets, energy, waste, water and air emissions as well as environmental protection expenditures. The United Nations Statistical Commission (UNSC) recently adopted the System of Environmental-Economic Accounting (SEEA)[12] as an initial version of an international standard for environmental-economic accounts. It will support development of climate change related statistics by enhancing the NSOs' work on environmental accounts, but the implementation of SEEA will also be a challenge to the NSOs. The SEEA contains the internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics on the environment and its relationship with the economy.

[11] Source: Climate change 1995, Economic and Social Dimensions of Climate Change: www.ipcc.ch/ipccreports/sar/wg_III/ipcc_sar_wg_III_full_report.pdf

[12] The System of Environmental-Economic Accounting (SEEA): unstats.un.org/unsd/envaccounting/seea.asp

Similar developments would be needed for improving linkage of climate change information with economic and social data.

Moreover, **identifying new statistics that must be incorporated into statistical systems to support climate change analysis**, such as monitoring the move towards greener consumption and production patterns, is a challenge for statistical systems.

1.3 Frameworks that can be used to structure climate change related statistics

Since the climate change related statistics cover a wide range of topics, the Task Force used different frameworks to delineate the scope of climate change related statistics, and to provide a structure to organise the statistics that fall within the scope.

Examining the frameworks helped with identifying the statistical subject areas that are related to climate change, and ensuring that all relevant topics are covered. Examples of variables under each statistical area are provided in Annex 2.The exercise did not intend to identify which is the "best", or most suitable framework for structuring climate change related statistics: each framework has its own purpose and advantages[13]. The following frameworks were analysed:

1. Driving forces – Pressure – State – Impacts – Response (DPSIR)
2. Framework for the Development of Environmental Statistics (FDES, 2013)
3. UN System of Environmental-Economic Accounting (SEEA, 2013)
4. Natural capital approach
5. Impact, mitigation and adaptation

1. <u>DRIVING FORCES – PRESSURE – STATE – IMPACT – RESPONSES (DPSIR) FRAMEWORK</u>

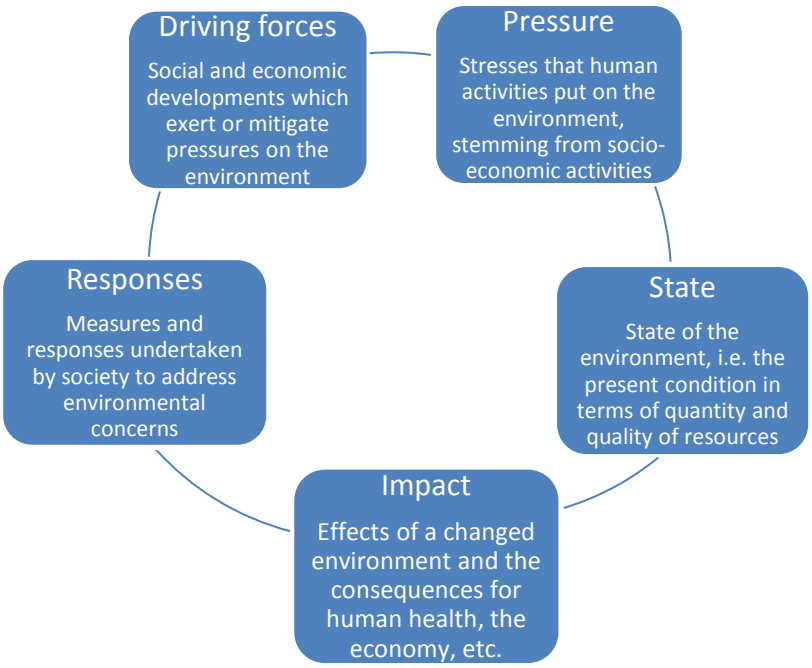
Climate change related statistics could be examined and structured according to the so called Driving forces-Pressure-State-Impact-Responses (DPSIR) model (see figure 1). The DPSIR model is used by the European Environment Agency (EEA) to "*structure thinking about the interplay between the environment and socio-economic activities.*"[14] DPSIR uses a systems analysis view towards assessing environmental phenomena. Although the model appears to be fairly simple, it can also represent a more complex system.

Organizing statistics relevant to climate change according to the DPSIR model can help to structure the different statistical areas that inform the various aspects of the climate change phenomenon, including –broad socio-economic developments, specific sources of greenhouse gas emissions, measures related to adaptation or curative action, etc.

[13] Scope of Climate Change Related Statistics, note prepared by the Task Force. www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.33/2012/mtg3/Scope_of_Climate_Change_Related_Statistics.pdf

[14] The DPSIR framework used by the EEA: ia2dec.ew.eea.europa.eu/knowledge_base/Frameworks/doc101182/

Figure 1. The Driving forces-Pressure-State-Impact-Responses (DPSIR) model



The DPSIR model can be examined in closer detail by looking at each of the five components separately. Examples of variables relevant to climate change for each area of the DPSIR model are given in Annex 2.

STATE

This component is interpreted to encompass the state of the climate system and the environment as affected by climate change. Information on the state of climate change includes data on atmosphere and climate, cryosphere (glaciers, arctic sea ice, snow cover) and marine biodiversity and its ecosystems**.** A good example of the state variables is the so called set of Essential Climate Variables (ECVs) of the Global Climate Observing System (GCOS)[15].

The main authorities responsible for these data are typically national meteorological institutes, and at the international level, the climate observation networks coordinated by World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP). Currently, in most countries the NSOs do not collect data on the state of the climate. They may, however, be involved in dissemination of these data alongside with other data produced by the NSO.

DRIVING FORCES

Driving forces encompass information on socio-economic developments, changes in life styles, levels of consumption and production, that exert or mitigate pressure on the environment and that are particularly relevant to climate change. These include for example data on population structure and movement; urbanization; changes in wealth and consumption and their impact on the demand for energy, transport, housing and food; changes in economic activity; internationalisation of the economy and tourism. Statistics on these topics are available in most NSOs.

[15] GCOS Essential Climate Variables: www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

PRESSURE

Pressures concern the actual greenhouse gas emissions, land use changes, resource consumption, direct damage to resources, and the underlying activities that produce the emissions, e.g. technology. The data relevant to the latter are referred to as "activity data" that statistical offices usually provide to emission inventory calculation. The emissions are estimated based on activity data and emission factors. The data required for calculating the emissions cover, for example combustion and production of fossil fuels in different industrial sectors, industrial processes, livestock, soil, land use and forestry, ozone depleting substances, waste and emission factors.

IMPACT

Impact of climate change can be viewed in two ways: the direct or indirect impact. First, the impact can be seen in terms of natural phenomena, for which data on water, air, soil, biodiversity, and ecosystems are relevant. Second, we can look at the socio-economic impacts of these physical changes: such as on agriculture and forestry, human health and the economy. The role of NSOs here is stronger when it comes to the latter type of data as the environmental data are often provided not by NSOs but by environmental agencies.

RESPONSES

The responses include actions to mitigate the effects and adapt to climate change. These can be expressed as official targets, for example as quantified emission limitations or reduction objectives under the Kyoto Protocol to the UNFCCC. Responses concern also economic opportunities generated as a result of climate change like eco-industries, technology exchange, green jobs and green growth. Methodology and sets of indicators are developed for some related issues such as "green growth" (e.g. under the Green Growth Initiative of the Organisation for Economic Co-operation and Development (OECD)[16]). Several statistics currently produced by NSOs are relevant for responses, e.g. statistics on environmental protection, investment, energy, prices, waste, employment, government finance and education.

2. FRAMEWORK FOR THE DEVELOPMENT OF ENVIRONMENTAL STATISTICS (FDES, 2013) AND IPCC SCHEMATIC FRAMEWORK

The primary objective of the Framework for the Development of Environmental Statistics (FDES) is to guide the formulation of environment statistics programs (see FDES 2013[17]). The concepts, terms and definitions used in the FDES are largely consistent with SEEA. FDES also allows describing climate change related statistics in all of its six main components: environmental conditions and quality; environmental resources and their use; residuals; extreme events and disasters; human settlements and environmental health; and environment protection, management and engagement. These are explained in more detail below. Examples of possible variables from FDES to measure climate change related phenomena are listed in Annex 2.

ENVIRONMENTAL CONDITIONS AND QUALITY

This component organizes information on environmental conditions and processes describing the foundations of ecosystems. It relates to the state element of DPSIR. The data relevant to climate change includes data on physical conditions (state of atmosphere, temperature, precipitation, sea level and sea ice, water system and desertification), soil and land cover,

[16] OECD work on green growth: www.oecd.org/document/10/0,3746,en_2649_37465_44076170_1_1_1_37465,00.html

[17] Framework for the Development of Environment Statistics (FDES) 2013: unstats.un.org/unsd/statcom/doc13/BG-FDES-Environment.pdf

biodiversity, state of and changes in ecosystems, flora, fauna and terrestrial and marine biodiversity, as well as trends and vulnerabilities of ecosystems and quality of climate etc.

The main sources for these data are meteorological and atmospheric monitoring networks and hydrological, geographical and geological institutions. Data on biodiversity and ecosystems are often collected and maintained by national environmental authorities.

ENVIRONMENTAL RESOURCES AND THEIR USE

Environmental resources or assets comprise the biophysical environment that provides benefits to people. The component is closely related to the asset and physical flow accounts of the SEEA Central Framework[18] and to both state and pressure elements of DPSIR. It comprises data on energy resources, land, biological and water resources that may be linked with climate change. Part of these statistics is available from the statistical systems, for example statistics on population, energy, agriculture, forestry, mining and land use.

RESIDUALS

This component contains statistical information on emissions of greenhouse gases and consumption of ozone depleting substances. This component mainly relates to the pressure element in DPSIR and to the physical flow accounts of SEEA. This information is usually produced as emission inventories, for which statistical systems provide activity data. Statistical offices often produce air emission accounts which allow distinguishing emissions due to production (by economic activity) and consumption.

EXTREME EVENTS AND DISASTERS

The occurrence of climate related extreme events and disasters, the impacts of the changing climate on people, economic and physical losses and effects on ecosystems belong to this component. These elements can be found in many parts of DPSIR, and they relate to the asset accounts of SEEA.

Data on natural extreme events are generally not supplied by the statistical system; the assessment of economic impact is often carried out by research institutions or insurance companies. Statistical offices are a limited source of information, e.g. via their supply of data on causes of death.

HUMAN SETTLEMENTS AND ENVIRONMENTAL HEALTH

Data on the environment in which humans live and work, living conditions and environmental health are part of this component. It includes data on housing vulnerable to natural disasters or extreme events; population exposed to air pollution; epidemic changes (vector borne diseases) and incidences, morbidity and mortality related to climate change.

Housing authorities, administrative records, censuses and surveys are likely sources for data on human habitat. The World Health Organization (WHO) is the global institution assessing the relationship between health and the environment, including climate change. Statistical systems typically provide useful data as part of statistics on population, health and mortality.

ENVIRONMENT PROTECTION, MANAGEMENT AND ENGAGEMENT

Information on protection, regulation and management of various climate change issues and concerns belongs to this component. It contains data on economic instruments, costs of mitigation and adaptation; governance and regulation, climate conventions; management systems to cope with extreme events; education and perception. This component relates to the response element in DPSIR and to the environmental activity accounts and related flows in SEEA.

[18] The System of Environmental-Economic Accounting (SEEA): unstats.un.org/unsd/envaccounting/seea.asp

Part of this information consists of qualitative data on projects and norms related to protection of the climate system and to the management of related extreme events. Some quantitative data, however, on costs of mitigation and adaptation measures, taxes and subsidies could be available from the statistical system. The role of statistical systems in measuring the effectiveness of economic instruments is also evolving.

Figure 2: Topics in the FDES that relate to climate change – organized by the IPCC framework

Climate Process Drivers

Sub-component 1.3: Environmental Quality	Sub-component 3.1: Emissions to Air
1.3.1.d Global atmospheric concentrations of greenhouse gases	3.1.1.a-b Total emissions of direct and indirect greenhouse gases (GHGs), by gas 3.1.2.a Consumption of ozone depleting substances (ODS), by substance

Climate Change Evidence

Sub-comp. 1.1: Physical Conditions	Sub-comp. 4.1: Natural Extreme Events and Disasters
1.1.1.a Temperature 1.1.1.b Precipitation 1.1.2.e.4 Sea level	4.1.1.a Occurrence of natural extreme events and disasters

Climate Change Impacts and Vulnerability

Sub-comp. 1.1: Physical Conditions	Sub-comp. 1.2: Land Cover, Ecosystems and Biodiversity	Sub-comp. 1.3: Environmental Quality	Sub-comp. 2.3: Land	Sub-comp. 4.1: Natural Extreme Events and Disasters	Sub-comp. 5.2: Environmental Health
1.1.2.a-c, g Lakes, rivers, reservoirs, glaciers 1.1.2.e.6 Area of sea ice 1.1.4.b.2 Area affected by desertifica-tion	1.2.1.a.1 Area of land cover 1.2.2.a-c Ecosystem characteristics and biological components 1.2.3.a Flora 1.2.3.b Fauna 1.2.4.a-b Forests	1.3.3.b Organic matter in marine water bodies 1.3.3.f Physical and chemical characteristics (of marine water bodies) 1.3.3.g Coral bleaching	2.3.1.j. Land use change	4.1.2.a-d People affected, economic loss, physical loss and effects on integrity of ecosystems	5.2.3.a Vector borne diseases

Mitigation and Adaptation

Sub-comp. 2.2: Energy Resources	Sub-comp. 6.1: Environment Protection and Resource Management Expenditure	Sub-comp. 6.2: Environmental Governance and Regulation	Sub-comp. 6.3: Extren Event Preparedness and Disast Management
2.2.2.a Production of energy from non-renewable and renewable sources	6.1.1.a Government environment protection and resource management expenditure 6.1.2.a Private sector environment protection and resource management expenditure	6.2.2.a Direct regulation 6.2.2.b Economic instruments 6.2.3.a Participation in MEAs and other global environmental conventions	6.3.1.a National natural extreme event and disaster preparedness and management systems

Source: FDES 2013, Figure 5.8, page 182.

The FDES report includes a section on topics in the FDES that relate to climate change. Figure 2 presents topics in the FDES that relate to climate change using the elements of the IPCC schematic framework. The IPCC framework represents anthropogenic drivers, impacts of and responses to climate change, and their linkages. An important difference between the IPCC schematic framework and the FDES is that "Socio-Economic Development" in FDES focuses on issues related to the environment, whereas the IPCC framework includes all socio-economic factors that are linked to climate change. The FDES also provides a list of concrete climate change statistics available in environment statistics (see FDES 2013, pages 183-185).

3. THE SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING

The objective of the System of Environmental-Economic Accounting (SEEA) is to organize statistical data to monitor the interactions between the economy and the environment. SEEA follows a similar accounting structure as the System of National Accounts (SNA) and uses concepts, definitions and classifications consistent with the SNA in order to facilitate the integration of environmental and economic statistics. SEEA is a multi-purpose system that can be used to generate a wide range of environmental statistics and indicators for many analytical applications. It is, therefore, potentially useful for deriving data and statistics related to climate change. SEEA is a flexible system in that its implementation can be adapted to countries' priorities and policy needs while at the same time providing a common framework and common concepts, terms and definitions. The Task Force plans to analyse the usefulness of the SEEA central framework for climate change related statistics.

….. (text to be provided)

4. NATURAL CAPITAL APPROACH

Another statistical framework that allows defining the scope of climate change statistics can be found in the body of thought around natural capital[19]. This approach links environmental quality and human well-being through the flows of ecological goods and services (EGS) from natural assets to humans.

NATURAL ASSETS

The environmental goods and services are essential for human well-being. Therefore maintaining the capacity of the environment to produce these flows is of central importance. Declines in this capacity will lead to declines in the EGS flows and consequent declines in well-being, other things being equal. According to the natural capital framework, the capacity of the environment to yield EGS flows arises from the numerous separately identifiable, structured groupings of living and non-living elements that constitute the environment. These "structured groupings" function as units to deliver EGS flows and have the characteristics of capital assets, similar to the assets in the economic context. These natural assets fall into three categories:

[19] The natural capital framework was given an early and full elaboration by Pearce and Turner (1990) in their popular textbook *Economics of Natural Resources and the Environment*. Herfindahl and Kneese (1974) drew on capital theory in an influential work on environmental economics nearly two decades earlier. The framework is today the subject of a large body of thought, much of which is found in the ecological economics literature (see Krishnan *et al.* [1995]). Daily (1997) offers an overview of natural capital from the perspective of ecology. Costanza *et al*. (1997) published a widely quoted study of the value of the world's natural capital in the journal *Nature*. Olewiler (2007) offers a more up-to-date commentary that reflects a Canadian perspective. Critical comments on the concept can be found in Victor (1991, 2007) and Hinterberger *et al*. (1997).

Ecosystems

Ecosystems are the most important and complex asset category. Ecosystems are structured groupings of living organisms and non-living matter that, given an on-going supply of solar energy, remain intact over long periods of time and yield continual flows of ecological goods and services. Ecosystems can be divided into two major groups: terrestrial and aquatic, but also the atmosphere can be seen as an ecosystem.

Land

Land provides space, whereas the other functions that are connected with land, such as the provision of timber, are captured in the ecosystem category. Space benefits humans in terms of the direct-use benefits associated with the occupation of space for dwellings, transportation infrastructure, agriculture, recreation etc. and these may be influenced by climate change.

Sub-soil resources

Sub-soil resources provide ecological goods such as minerals, metals, fossil fuels and water. Sub-soil resources represent stocks from which ecological goods are withdrawn for use in human activity. These materials provide direct-use benefits as inputs into industrial processes and home heating. Many of the resources humans require are found underground in deposits of various minerals, liquids and gases. These deposits are fundamentally different from ecosystems in that they are subject to permanent depletion as a result of use. Ecosystems, in contrast, have the ability to regenerate themselves over time if their use is kept within sustainable limits

ECOLOGICAL GOODS AND SERVICES

The natural assets – ecosystems, land and sub-soil resources –produce EGS. The relatively stable and predictable climate that has prevailed for much of modern human history is one of the most important ecological services. Possible disruptions to this service due to climate change would cause various consequences. Examples of possible variables to measure climate change related phenomena under the natural capital approach are listed in Annex 2.

Potential variables can be identified by assessing impacts of disruptions to the stable and predictable climate. These could include changes in the provision of space; flood protection service offered by forests and wetlands; spread of vector-borne diseases; transportation services offered by rivers, lakes and oceans; recreational opportunities; and aesthetic, cultural or existence value of the environment. The impact could also been seen as changed flows of ecological goods, for example in food production, marine resources, forest products, water availability and quality.

To define statistical variables to measure climate change through capital approach, one would first identify the EGS produced by the assets that are potentially affected by climate change.

The five categories of statistical variables would be:

7. Capacity of natural assets to deliver EGS.
8. Flows of EGS from natural assets to the human sphere.
9. Flows of waste materials and energy that leave the human sphere and return to the environment.
10. Flows associated with efforts to reduce the scale of waste material and energy flows that are released to the environment.
11. Flows associated with efforts to adapt to the loss or reduction of EGS.

To summarize, the scope of climate change statistics as defined by the natural capital approach includes statistics related to the atmosphere; marine, forest, freshwater and groundwater ecosystems; agricultural ecosystems and land (as the provider of space).

5. IMPACTS, MITIGATION AND ADAPTATION (IMA)

Another way for categorizing climate change related statistics is in line with how the climate change discussions typically are structured – impacts, mitigation and adaptation. Such a framework is simpler than the ones presented above. It provides a direct link to major strands in climate policy, but lacks a detailed structure as it allows for only three categories of statistics.

IMPACTS

Impacts, as considered here entail broadly the **consequences** of climate change. The natural impacts include heat waves, rising oceans, retreats of glaciers, droughts etc. The socio-economic impacts include reduced crop yields, changes in crop patterns, changes in disease patters etc.

Although statistical systems provide a lot of data relevant for analysing the impact of climate change, a big challenge for statistical systems here is related to causality. This concerns especially the wider socio-economic consequences of climate change. Specific changes in socio-economic phenomena (e.g. crops in agriculture) may be due to other reasons than climate change, for example changing food preferences, discontinuation of specific subsidies etc. Analysing the cause-effect relationship goes beyond the task of the official statisticians. This should rather be the job of specialized analysis or targeted studies but the task of official statistics is to provide data that can be used for such analysis.

MITIGATION

Mitigation is "*an intervention to reduce the sources or enhance the sinks of greenhouse gases*".[20] Mitigation can be considered in broad terms to encompass efforts to control the **causes** of climate change, essentially to reduce greenhouse gas emissions. Relevant statistics here would include data on the emissions themselves and all the underlying activities (e.g. the activities in the different inventory sectors such as energy, industrial processes, agriculture and waste) as well as the broader socio-economic phenomena such as population growth, urbanization, industrialization, etc. that have an impact on increased emissions. Statistics relevant to mitigation also include the measures taken to address these causes, i.e. any emission reduction action which can be statistically quantified, for example energy taxes, transport taxes, data on the carbon market and trade, and on renewable energy resources.

ADAPTATION

Adaptation is "*the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*."[21] Statistics relevant to adaptation cover the actual **actions and measures** taken by governments and society to adapt to the inevitable consequences of climate change as far as they are statistically quantifiable. Measures typically listed in so called National Adaptation Strategies may not always be expressed in quantifiable terms. Furthermore, statistics relevant to education are also needed as educational work is important for effective adaptation.

FINDINGS FROM THE ANALYSIS OF DIFFERENT FRAMEWORKS

Each framework presented above provides a different viewpoint to climate change related information. Many of the statistics called for by the frameworks are already available in the statistical system, but may need to be developed further to be suitable for the purposes of analysis linked with climate change. The main question is not which framework is the best to organise

[20] IPCC definition: www.ipcc.ch/publications_and_data/ar4/wg2/en/ch18s18-1-2.html
[21] IPCC definition in Climate Change 2007, Impacts, adaptation and vulnerability: www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf

climate change related information, but how all of them help to define the scope of climate change related statistics.

The Task Force used the Classification of Statistical Activities (CSA Rev. 1, 2009) as a tool to summarise the coverage of statistical issues in the examined frameworks. The CSA provides a comprehensive list of the topics covered by the statistical system. The table is presented as Annex 3. The table also distinguishes between statistical areas that are closely related, related and indirectly related to climate change. The Task Force used the CSA for analysing both the coverage of each framework and for defining the scope of climate change related statistics.

The challenge is deciding *what variables* should be measured within the scope of climate change related statistics. While both DPSIR and IMA are useful for organizing variables into categories, the frameworks say little about what variables should be collected in the first place. Both climate science and climate policy provide guidance as to what should be collected. The DPSIR and IMA are highly flexible and comprehensive and any variable that might be related to climate change can fit into the framework. Therefore, a combination of climate science/policy advice and either the DPSIR or IMA framework could be used to structure climate change related statistics.

One challenge of the DPSIR framework is deciding which variables go into which component of the framework. For example, it is not always obvious if some element belongs to the “state” or the “impact” component. This could be solved by considering biophysical impacts part of the “state” component and by including only socio-economic impacts under the “impact” category. Furthermore, analysing causal relations and factors that contribute to change is typically done outside of the statistical system. Has the “driver” contributed to climate change and is the “impact” really a result of changing climate? The attribution of weather events to climate change or to natural climate variability is difficult. This task falls into the competence of climate science, not statistics. In this context, the DPSIR and IMA should be treated as a tool for organizing the climate change related information, not as a model for analysing causality between its parts.

FDES, on the other hand, covers a number of areas relevant to climate change. It does not emphasize the causes of climate change or include all socio-economic impacts of climate change. FDES includes some of the implications to human health and well-being from the viewpoint of environment only. FDES does not consider economic possibilities or limitations caused by climate change nor the impact of globalization and trade to climate. FDES can be very helpful in structuring information available from environmental statistics but should be complemented with additional social and economic statistics.

The natural capital approach offers a comprehensive and rigorous means of defining the scope of climate change statistics by focusing on the links between environmental quality and human well-being. It is based on a robust scientific literature and is part of a broader effort to expand the traditional notion of capital into other domains. The approach constrains the scope of climate change statistics to those variables that are directly relevant to measuring natural assets and the flows between these assets and the human sphere. For example, it limits measures of human health issues to just those that are attributable to the loss of EGS flows due to climate change. Economic measures are limited to activities that are undertaken either to mitigate the causes of climate change or to adapt to the associated loss of EGS flows.

The Task Force does not advocate for any particular framework. Instead, it rather proposes a pragmatic approach to divide climate change related statistics into two groups: statistics directly needed for the compilation of greenhouse gas inventories and other climate change related statistics. This approach is explained in the next section, and it is also underpinned by the Task Force's mandate (see Annex 1). The ’other climate change related statistics’ are further divided to statistics on the drivers of climate change, and to statistics on its consequences. The statistics on the consequences of climate change would include statistics on the impacts of climate change, statistics related to mitigation, adaptation and vulnerability.

1.4 Conclusions on the scope of climate change related statistics

The need to measure climate change has spurred the development of a wide variety of data. To identify how statistical systems could better respond to the need for climate change related statistics, it is first necessary to define the scope of such statistics. The Task Force devoted considerable discussion to this issue; in particular, through the above examination of different frameworks and approaches used in the compilation of environmental statistics and also through evaluation of user needs. As a common feature to all frameworks and approaches examined, they suggest the need to measure the factors that are the **cause** of climate change, the **consequences** of climate on human and natural systems and the **efforts** of humans to avoid climate change and live with the consequences.

The conclusion of these discussions is that as climate change impacts the environment and society through complex interactions and cause-effect relations, the conceptually based definition of climate change related statistics would necessarily be wide and exhaustive. Climate change touches upon a broad range of human activities – from energy use to transportation, waste generation, agriculture, manufacturing and tourism etc. Indeed, few human activities are not related somehow to climate change, either as a contributing factor or via an impact. Climate change influences a wide range of natural phenomena: rainfall, temperatures, ocean and air currents and ecosystems that have an impact on human activities.

In the very broad sense, the Task Force **defines the scope** of climate change related statistics to include:

> *Environmental, social and economic data that measure the human causes of climate change, the impacts of climate change on human and natural systems, the efforts of humans to avoid the consequences as well as their efforts to adapt to these consequences*.

Whereas climate change is multi-disciplinary and anchored largely in the natural sciences, the statistical system is focused largely on anthropomorphic or human systems and provides data for administrative regions within national boundaries.

A broad definition is, therefore, only a starting point for statistical offices wishing to improve climate change related statistics. A pragmatic approach is needed to narrow the scope to those areas where national statistical offices' involvement is most important. These are areas where the links between human and natural systems is most important in terms of understanding climate change – both from the point of view of its causes and its consequences.

First, to define the scope in the context of official statistics and national statistical offices, the Task Force decided to make a difference between the climate change related statistics and **climate change statistics**. The latter includes data that measures climate and weather directly; for example, temperature and precipitation. These data are frequently, but not always, collected and analysed by other agencies than national statistical offices, for example by meteorological organizations. When speaking about the role of statistical systems, the focus is on **climate change "related" statistics** rather than on the climate change statistics. Climate change related statistics refer to those environmental, social and economic statistics that measure climate sensitive phenomena.

Second, the Task Force suggests a pragmatic approach to consider data for greenhouse gas inventories separately from the climate change related statistics. The inventories have a specific role since the reduction of emissions is at the core of the response to climate change. A global management system has been set up around the Convention and the Kyoto Protocol to measure greenhouse gas inventories, and well-developed systems and methodologies are in place for their measurement. There are, however, many areas in which official statistics should improve their support to GHG inventories.

Third, for practical purposes the Task Force splits climate change related statistics into groups of *environmental, social and economic data that measure:*

1. **Greenhouse gas emissions**: the part of *human causes of climate change* that deals with emissions directly*,*
2. **Drivers**: the part of *human causes of climate change* that deals with sources and causes of emissions*,*
3. **Impacts:** *impacts of climate change on human and natural systems,*
4. **Mitigation:** *efforts of humans to avoid the consequences,*
5. **Adaptation:** *efforts to adapt to these consequences*.

The first two groups, greenhouse gas emissions and drivers, describe causes of climate change. The latter three – impacts, mitigation and adaptation – the consequences of climate change.

DATA FOR GREENHOUSE GAS INVENTORIES

Statistics about the human activities that lead to the build-up of greenhouse gases in the atmosphere are among the most important climate change related statistics produced by the statistical system. According to the IPCC inventory methodology[22], the categories of data required include statistics on energy use, industrial processes, agriculture, waste generation, land use and forestry and use of specific products that are themselves (or contain) greenhouse gases (e.g., solvents).

Key statistics concerning energy[23] include energy balances along with more detailed sectoral statistics related to energy use; for example, breakdowns of energy use in transport. Key statistics on industrial production include cement production, chemical production, metal production and halocarbon production and use. Statistics on other economic activities including agriculture, forestry and waste management are also relevant.

CLIMATE CHANGE RELATED STATISTICS OTHER THAN THOSE RELATED TO GHG INVENTORIES

Climate change related statistics, other than GHG inventories, include the data required for analysis and monitoring of the causes and consequences of climate change for human and natural systems, and the efforts to mitigate and adapt to these consequences. It is not the task of statistical systems to analyse to what extent a specific phenomenon has been caused by climate change. The task of official statistics is to provide the data that are necessary for such analysis.

Drivers

To analyse the causes of climate change beyond GHG inventories, various economic variables like gross domestic product (GDP), population, underlying drivers behind emissions, such as energy use, transport, etc. are needed. Such data could help track progress towards official emission reduction targets. Several such indicators already function as core indicators informing climate policy (e.g. GHG emissions per capita, carbon intensity of the economy, etc.). The use of matched data sets that allow for input-output and other types of econometric analyses are also important for examining production and consumption patterns and their embedded carbon dioxide ($CO_{2)}$ emissions. Statistics can play an important role here in informing these integrated economic-climate analyses, which are widely used for developing mitigation policies.

[22] The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: www.ipcc-nggip.iges.or.jp/public/2006gl/

[23] CO_2 emissions from energy use (combustion of fossil fuels) amount to 70-90% of total anthropogenic CO_2 emissions. *Revised 1996 IPCC Guidelines for National Greenhouse Gas inventories*: Reference Manual, p. 1.8. www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

Consequences

Statistics under the general title of consequences include those on the impacts of climate change and on vulnerabilities to them, on the efforts to mitigate these impacts and on the efforts to adapt to them, for example:

1. Statistics related to the impacts of climate change include inter alia food production, water availability and use, timber production and disease incidence;
2. Statistics related to mitigation include, for example, expenditures on energy efficiency improvements, renewable energy and other technologies to reduce greenhouse gas emissions. Various datasets are also needed for making judgements on impacts of different mitigation efforts, for example to assess the impact of carbon pricing on economic sectors;
3. Statistics related to adaptation can include, for example, expenditures on infrastructure improvements (breakwaters, hurricane-resistant housing) and structural changes (shifts in employee and output). Adaptation strategies require risk assessments and data on vulnerabilities. The statistics include inter alia population and infrastructure at risk from extreme weather events, employment and output in climate-dependent industries and health status of key populations (youth, the elderly and the infirm).

The above listing of statistics is not comprehensive, but begins to provide a sense of what a set of climate change related statistics might look like. The following chapters will help identify specific statistical domains for improvement depending on how relevant and how well-developed they currently are for the purposes of informing on climate change. This can help setting priorities for further work at NSOs and future development at international levels.

2 GREENHOUSE GAS INVENTORIES AND OFFICIAL STATISTICS

This chapter sets out the role of national statistical offices (NSOs) in support of compiling national greenhouse gas (GHG) inventories. All Annex I countries to the United Nations Framework Convention on Climate Change (UNFCCC) are required to compile a national greenhouse gas emissions inventory and submit it to the UNFCCC annually.[24] This chapter considers the current and potential role of NSOs in the *national systems*[25] that produce these inventories. The chapter aims to:

- assess the user needs of greenhouse gas inventory producers for statistical data;
- examine the current involvement of NSOs and existing data with relevance to inventories;
- identify major gaps and areas where NSOs could make an improved contribution;
- consider how NSOs could streamline and improve their work in support of inventories.

Inventory compilation incorporates various statistical activities. These include collecting basic data on a variety of economic activities[26] and making them available to inventory compilers; selecting the appropriate methods and emission factors; estimating GHG emission sources and sinks[27]; implementing quality assurance/quality control (QA/QC) procedures; and verification of national data. Inventories consist of standardised tables based on a common reporting format (CRF) and should be accompanied by a written report documenting the methodologies and data sources that have been used (a national inventory report).

The role of NSOs in the national system and their involvement in the compilation process varies from country to country; for example, in some countries the NSO is not even the source of the activity data, whilst there are also countries where the NSO acts as the inventory compiling authority, coordinating the whole process. However, a role that many NSOs play is to ensure that relevant activity and other statistical data are collected and that they are shared with national GHG inventory compilers.

The question this chapter considers is whether, through greater involvement in the compilation process, NSOs would be able to improve to this process, and thereby improve the quality of inventories and the level of consistency between countries.

2.1 User needs

Each national GHG inventory provides information on emission trends that is relevant to policy makers in designing climate mitigation policies and assessing the impact of those policies. Moreover,

[24] Annex I countries include the industrialised countries that are members of OECD and countries with economies in transition, such as the Baltic States, and several Central and Eastern European States. For example, most European countries, Australia, Canada, Japan, Russian Federation, New Zealand and United States are part of Annex I countries. In addition to Annex I countries, a number of other countries compile greenhouse gas inventories for their own purposes. Furthermore, the 17th UNFCCC Conference of the Parties in Durban (in November 2011) agreed to put in place by 2015 a global protocol to be implemented from 2020 which will requires all countries (not only Annex I) to submit annual inventories.

[25] Article 5.1 of the Kyoto Protocol (Read: Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol) requires that Annex I Parties to the Convention have a National System in place for estimating anthropogenic GHG emissions and removals and for reporting and archiving the results. Guidelines for national systems define the national system as includes all institutional, legal and procedural arrangements made for estimating anthropogenic emissions and removals, and for reporting and archiving inventory information: www.ciesin.columbia.edu/repository/entri/docs/cop/Kyoto_COP001_019.pdf

[26] In the language of the UNFCCC, these are referred to as "activity data".

[27] The source/sink sectors defined by the IPCC are: 1. energy; 2. industrial processes; 3. solvent and other product use; 4. agriculture; 5. land use change and forestry; 6. waste; and 7. Other (www.ipcc-nggip.iges.or.jp/public/gl/invs1.html). A sink is a natural or artificial reservoir, physical unit or process that stores greenhouse gases, for example forests and underground or deep sea reservoirs of carbon dioxide (CO_2).

all national inventories undergo a thorough and independent review by international groups of experts on an annual basis. In both these compilation and review processes, more and better quality activity data are demanded.

The users of data with respect to GHG inventories can be classified as: (1) the inventory compilers themselves; (2) the inventory reviewers, and; (3) climate change analysts. Each of these groups has different needs, and each will potentially be looking to NSOs to help address these needs. Whereas the first group are mostly interested in the availability of good quality activity data to estimate GHG emissions, the focus of the second group is on the review and assessment of the quality of these estimates. The last group has become increasingly prominent in recent years. Their task is often to interpret the inventory information for the policy makers, the media and the general public.

From the perspective of inventory compilers, the most obvious role of NSOs is **to provide high quality activity data**. The reported GHG emissions are heavily dependent on these data; the better the quality of the activity data, the higher quality the GHG emissions inventory.

From the inventory reviewer perspective, it is often difficult for reviewers to **ascertain the quality** of the underpinning activity data. Greater involvement of NSOs in explaining the quality of these data could improve GHG inventories and ensure greater consistency between inventories and other statistics.

A risk of insufficient involvement of NSOs in the inventory compilation and review processes is that additional, and even duplicate, data collection systems may be established. The costs of these systems are high, they increase the reporting burden of respondents and may yield data that are inconsistent with official NSO statistics. In many cases, inventory data needs can be better met by incorporating additional questions into existing NSO data collections with limited additional cost and respondent burden and the benefit of full consistency with official statistics.

Considering analysts of climate change and inventories, they look for **detailed data** to find factors that are key to understanding the reasons behind increases and decreases in greenhouse gas emissions. For example, emissions can decrease as a result of "fuel switching" in the power supply sector (e.g. from coal to gas). This information can be derived from the activity data reported in GHG inventories. Emissions can also decrease if renewable energy resources, such as wind or solar power or energy, replace fossil-fuels to cover part of the final electricity consumption. This activity data cannot be found in GHG inventories since renewable resources are not a source of emissions. Similarly, **linking emissions to socio-economic data,** explanatory variables and other data produced by NSOs, will help to provide a more complete picture of the underlying reasons for increasing or decreasing trends in emissions. Analysts are also seeking **timelier** information, to meet the growing demands of policy makers and the public, and to raise the profile of climate change information alongside comparable economic and social information.

Based on the stakeholder interviews carried out by the Task Force, analysts especially look for NSO data to analyse GHG emissions by economic sector. Examples of types of data needs mentioned:

- Economic output by activity, imports, exports at national and regional levels;
- Emissions by sectors and products;
- Geo-referenced land use and land management data;
- Energy use by economic activity.

2.2 NSO involvement today

GHG inventories require a number of different statistical inputs as the basis for their calculation. A Eurostat publication, *Using official statistics to calculate greenhouse gas emissions*[28], provides a useful overview of the data that are available within statistical systems that may be used for estimating or analysing GHG emissions. These include, but are not limited to, activity data related to **energy production and consumption, agriculture, forestry, mining, waste generation, manufacturing, transportation and land cover**. While NSOs are usually not directly responsible for the GHG inventories, they have a crucial role to play in ensuring their quality through the provision of such activity data. Indeed, most activity data needed for the GHG inventories come from official statistics and many of these data are produced as statistics in their own right by NSOs.

A 2011 UNECE survey[29] showed that NSOs have a considerable range of experience in supporting inventory compilation. The survey showed that more than 75 per cent of NSOs (37 countries) said they were in some way involved in the work related to greenhouse gas inventories: 20 were involved only in providing activity data, 12 participated in the calculations of emissions based on activity data[30], 5 were responsible for most of the inventory calculations and 4 of these actually reported their countries' inventories. Most NSOs who participated in the process did so by collaborating with other institutions, such as ministries or research bodies, and under the auspices of special committees or expert working groups.

To classify the range of national experiences, three levels of NSO involvement can be identified:

4. provision (and/or publication) of activity data
5. inventory compilation (including calculations of emissions)
6. inventory submission (to meet international reporting obligations)

In order to meet the increasing requirements for energy monitoring, all countries of the European Union (EU) and several others are producing a coherent and harmonised system of **energy statistics**. These are a source of information on energy consumption, energy dependency, energy intensity of the economy, electricity generation and statistics on renewable energy sources, and serve as an important source data for GHG inventories. The **energy balances** often serve as a basis for air emission calculations.

The most common sectors in which NSOs are involved are energy, agriculture and industrial processes. The table below illustrates the number of NSOs, among those who replied to the UNECE survey, who actively collect or calculate data for the emission inventories. Even though data on these topics are available in most statistical systems, not all NSOs actively support inventory compilation or take their data needs into account.

Table 1. Number of NSOs, in the UNECE survey, that collect or calculate data by IPCC source/sink categories.

	Data collection	Emissions calculation
Energy	21	8
Agriculture	19	7
Industrial processes	18	9
Land use change and forestry	13	1
Waste	12	4

[28] Using official statistics to calculate greenhouse gas emissions. A statistical guide: epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-31-09-272/EN/KS-31-09-272-EN.PDF

[29] The UNECE survey report: www.unece.org/stats/climate.html

Solvent and other product use	7	2

As can be seen from the table, a smaller number of NSOs is also involved in the inventory compilation process. Out of the 12 NSOs that were involved in GHG inventory calculations, in most cases, the NSO is responsible for the calculation of specific sectors. In some cases, the NSO has no overall responsibility for any single sector, but contributes in some way across all sectors. Sometimes the reported involvement of NSOs may be rather limited. For example, in some EU countries the inventory compilers first take the activity data and estimate emissions using emission factors. Only in the second step the NSOs take the resulting inventory data and re-allocate the emissions to industries (ISIC/NACE) and the household sector that produced them.

The UNECE survey also explored the involvement of NSOs in the calculation of specific greenhouse gases. Of the NSOs that responded, 13 are involved in the calculation of at least one of the six major greenhouse gases, most commonly carbon dioxide (CO_2), methane (CH_4) or nitrous oxide (N_2O). The same number of NSOs is involved in calculating some of the emissions of indirect greenhouse gases, most often those of nitrogen oxides (NO_x) and sulphur dioxide (SO_2).

In respect of international reporting, of the countries who responded to the UNECE survey, more than half were involved in reporting to international organizations. These included Eurostat, the UNFCCC, the European Environment Agency, the Organisation for Economic Co-operation and Development (OECD), the Economic Commission for Latin America and the Caribbean (ECLAC), the United Nations Statistics Division (UNSD) and the Commonwealth of Independent States (CIS).

It should be noted that a relatively small number of NSOs is involved in some way in all three phases of the process. There are, in fact, 5 countries where the NSO is actually responsible for most of the inventory compilation; this applies for Finland, Israel, Norway, Turkey and partially for Sweden. In Sweden the NSO produces a large share of the results as a service commissioned by other government bodies.

It seems that in 11 countries, the NSO does not have any involvement in the inventory process.

A number of NSOs are also involved in other activities related to the GHG inventories. These include:

- Quality assurance of underlying datasets and final results;
- National coordination of work for the greenhouse gas inventory;
- Bridging the gap between economic activity classifications and those used for GHG;
- Providing consumption based emissions estimates (e.g. by end user sectors, or consumption of fuel, raw materials or products);
- Providing experts for UNFCCC reviews, international revisions and consulting;
- Disseminating results via databases and thematic publications.

Of the NSOs who are involved in the inventory process, a number are considering making improvements to the way the work is carried out in their country. This could potentially concern activities such as extending the coverage to take account of new data, developing new methodologies, or improving coordination of work between the responsible organizations within their country. Some NSOs are also preparing for possible new requirements arising within the European Union, in relation to the EU Climate and Energy Package, as well as from any other international agreement, such as the second commitment period of the Kyoto Protocol.

In respect of the international negotiations, the majority of NSOs who responded to the survey said that they would find it useful to discuss how the measurement, reporting and verification (MRV) approach for inventory compilation applies to NSOs.

The following case studies are presented to illustrate how differently the national systems for GHG inventories are currently organised in countries. The challenges in producing emission inventories and the cooperation among institutions depend on the way of organising the work in each country.

Country case studies: Ways of organising the national systems for greenhouse gas inventories and the NSO role.

ALBANIA – NSO to be involved in the future

The Albanian Ministry of Environment, Forests and Water Administration presented at the expert meeting their experience in developing their capacity for compiling emission inventories. In the previous inventory rounds, data availability and quality presented a barrier to improving the accuracy of the inventory. As a consequence, Albania is setting up official institutional arrangements for emission inventory compilation. This requires decisions on methodologies and emission factors, finding data sources, setting up networks and a framework for management and quality assurance.

In Albania the current legislation does not oblige data providers to submit their data for emission inventories, but amendments are underway. In addition, the NSO is expected to increasingly contribute to the emission inventories in the future, after development of national energy statistics and the energy balance in line with EU requirements. Albania's experience supports the need to develop the capacity for and involvement of official statistics in emission inventory compilation.

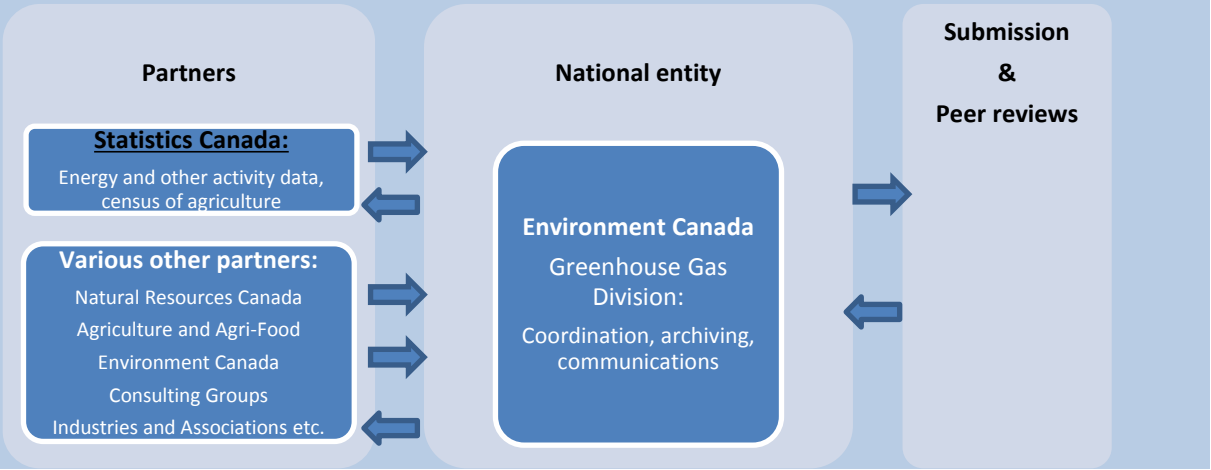
AUSTRALIA – NSO making quality checks to GHG as part of national statistics

In Australia, the Department of Climate Change within the Australian Government is responsible for all aspects of GHG inventories and their submission to the UNFCCC. The department estimates emissions using the Australian Greenhouse Emissions Information System and, for the land use change and forestry sector, the National Carbon Accounting System. The department also uses a pool of consultants for specialised tasks.

The GHG inventories are primarily based on activity data published by Australia's principal economic statistics agencies, the Australian Bureau of Statistics (ABS) and the Australian Bureau of Agricultural and Resource Economics. ABS has a prominent role in the coordination of GHG inventories as part of national statistics, and reviewing data quality. ABS provides agricultural activity data and some commodity and energy-related data.

CANADA – NSO a partner in data provision

In Canada, Environment Canada's Greenhouse Gas Division is the national entity with responsibility for the preparation and submission of the GHG inventory to the UNFCCC. The Greenhouse Gas Division has defined roles and responsibilities for the preparation of the inventory, both internally and externally. Statistics Canada is one of the main providers of underlying activity data.

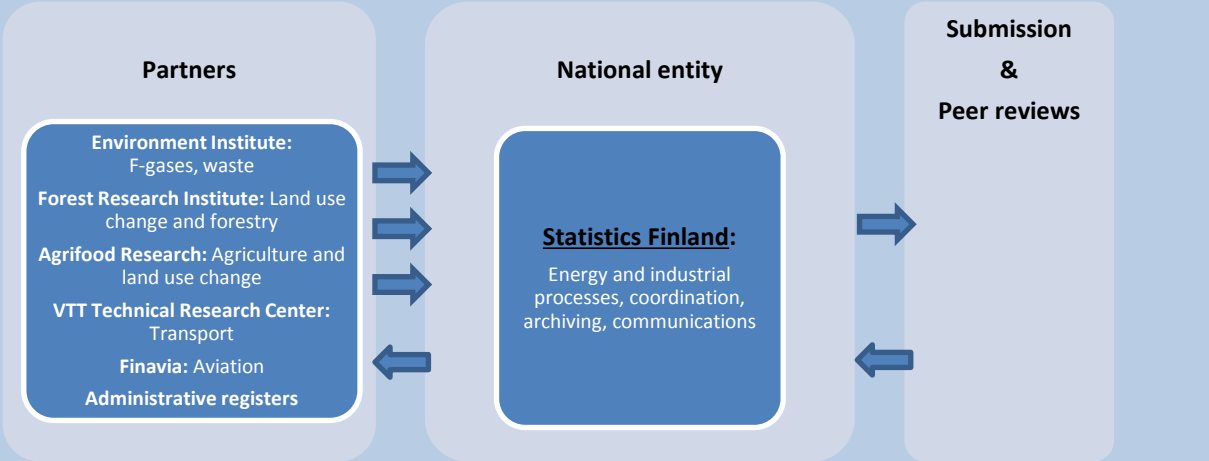


FINLAND – NSO as the national entity

The Government in Finland noted problems associated with emissions data being spread between several sources, and assigned the responsibility for coordinating the inventory compilation to Statistics Finland in 2003. Since then, Statistics Finland has been the national entity with overall responsibility for the general administration, quality management of the inventory, and of communication with the UNFCCC.

The legal framework is defined by the Resolution of the Finnish Government of 30 January 2003 on the organisation of climate policy activities of Government authorities. It is further defined by an agreement between the Ministry of the Environment and Statistics Finland.

A presentation by Statistics Finland at the expert meeting in November 2012 conveyed the lessons learned by an NSO acting as the national authority for the emissions inventory. The advantages of an NSO coordinating the work include the ability to achieve close collaboration with energy and other source statistics, well-developed quality assurance methods, and the ability to make detailed comparisons with confidential source data. A major advantage is also that no additional data collection is needed for the emission inventory in Finland. On the downside though, the NSO cannot publish company-specific information, unlike other compilers. In Finland, too, a number of areas have been identified for improvement, such as the need for energy statistics to be produced more frequently for the purposes of emission inventories.

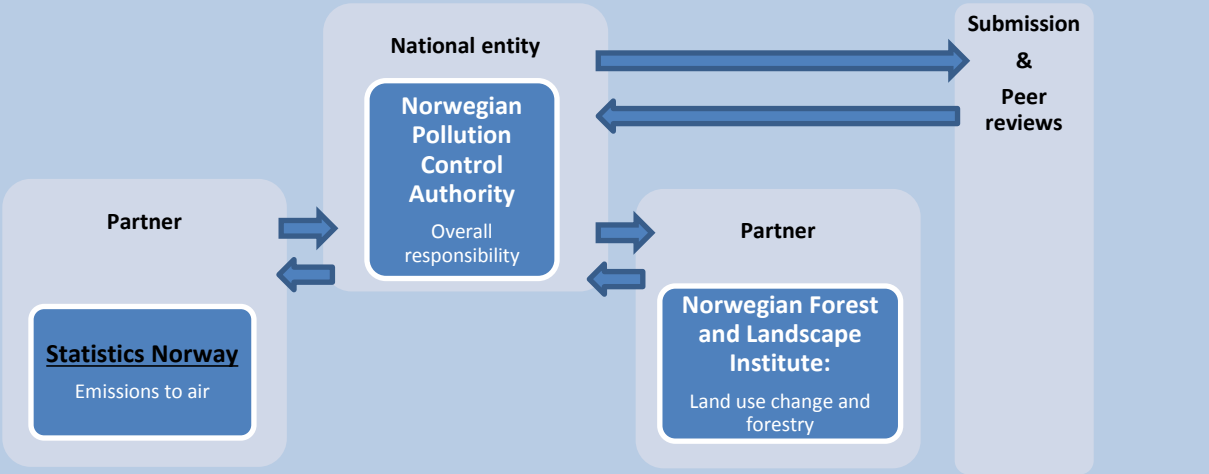


THE NETHERLANDS – NSO provides data to a private firm appointed as national entity

In the Netherlands, the Ministry of Housing, Spatial Planning and the Environment (VROM) has appointed a private agency, SenterNovem, as the national entity. Most general statistical data are provided by Statistics Netherlands as part of their legal tasks. Data on agriculture, land-use change and forestry are provided by agricultural institutes and waste data are collected by the Waste Coordination Platform from SenterNovem under a longer term assignment from the Ministry. Data provision is based on agreements signed with the above organisations. In this case, the national entity has a centrally accessible archiving system with the exception of confidential data that are maintained and archived by the producer.

NORWAY – NSO in close triangular cooperation

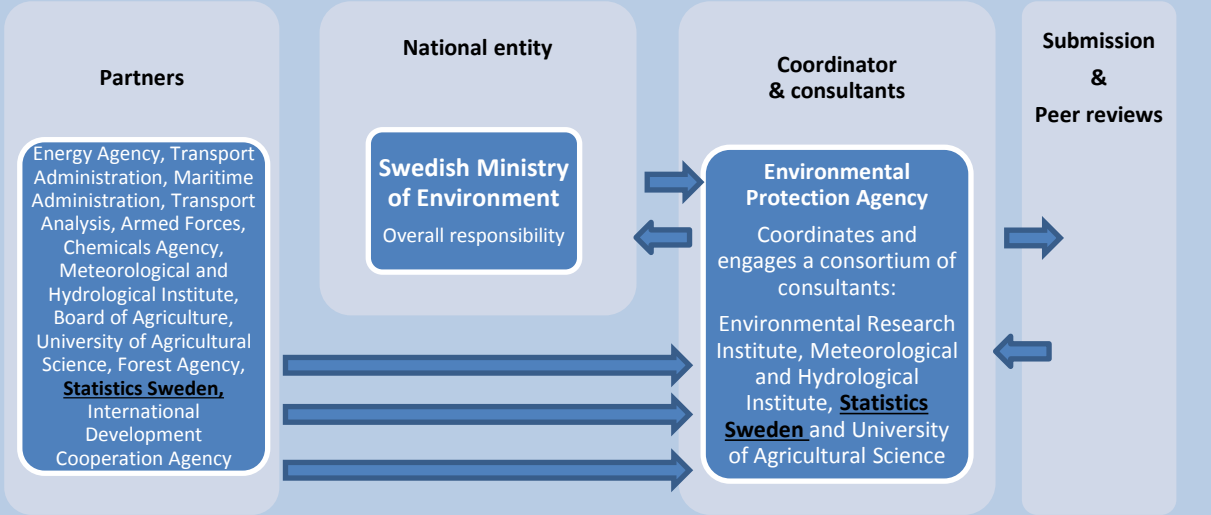
The Norwegian national system for GHG inventories is based on triangular cooperation between the Norwegian Pollution Control Authority, Statistics Norway and the Norwegian Forest and Landscape Institute. The Pollution Control Authority has been appointed by the Ministry of the Environment as the national entity, and the other two agencies have signed agreements with the national entity. Statistics Norway is responsible for statistics on emissions to air. The main emission model has also been developed by Statistics Norway.



SWEDEN – NSO provides data and calculations as a commissioned service

The Swedish Ministry of Environment is the single national entity that has overall responsibility for the inventory, but the Swedish Environmental Protection Agency has specific responsibilities for coordinating the production of the inventory, maintaining the reporting system and quality assurance of the inventory. Statistics Sweden is part of a consortium of consultants and produces a large share of the material submitted to the UNFCCC as a commissioned service to the Swedish Environmental Protection Agency. This type of organization differs notably from most countries.

The work is regulated by a framework contract that runs for nine years. The inventory work is organised as a project run by a project management team with one person from each organization. The Meteorological and Hydrological Institute is responsible for the compilation of gridded emission data. Statistics Sweden is responsible for energy, agriculture and parts of waste sector, but is also involved in industrial processes. The University of Agricultural Sciences is responsible for the land use change and forestry sector. The Environmental Research Institute is responsible for industrial process, solvents and other products use and parts of the waste and energy sectors.



UNITED KINGDOM – NSO coordinates the work of the national entity

In the United Kingdom, the Department of Energy and Climate Change (DECC) is the entity with responsibility for the overall management and strategic development of the GHG inventory. DECC also produces official statistics on energy and climate change. A global, sustainability consultancy, Ricardo-AEA, is the delegated inventory agency with responsibility for compilation and reporting of the GHG inventory. However, the work is effectively coordinated by the NSO of the United Kingdom (UK); the UK has statisticians bedded-out within policy departments, and all aspects of the inventory work, from compilation to reporting, are overseen by a statistician representing the NSO. DECC has also established the National Inventory Steering Committee which is an inter-departmental committee that ensures cross-Government coordination of inventory work, and prioritises inventory improvement work.

2.3 Data gaps and challenges of greenhouse gas inventories

NSOs have a lot of data that are needed for compiling GHG inventories. The challenge is that these data were collected for different purposes and may be organised in a way which makes it difficult to extract data for GHG inventories. Inventory compilers need to use these data in new ways and for new purposes.

Some of the activity data are readily available from current official statistics, whereas some closely related **variables are not available** even if they could sometimes be easily added to data collections. For example, activity data include the number of animals by type and age, but not information regarding how farmers manage the manure from the animals. The emissions from animal waste are very much dependent upon that information. Similar cases exist for the other inventory sectors.

Improved data are needed also on the production of heat and electricity for own use by households and enterprises and on renewable energy sources (e.g., solar energy, fuel wood, biogas, animal dung, wind, heat pumps/geothermal sources).

The stakeholder interviews revealed that **access to disaggregated source data** continues to be a challenge (both the level of detail of published data and access to microdata). A question has also arisen about whether the level of detail required for inventory compilation is too excessive, and whether it would be possible to achieve a better balance between costs of data collection and accuracy of results. Examples of practical data gaps highlighted by the interviews include:

- Economic information that could be connected to policies and measures;
- More disaggregated information, higher level of detail both with regard to economic sectors and geographic breakdown and finer scale of demographic and socio-economic data;
- Geo-referenced annual parcel level data on land use and management as well as soil carbon parameters;
- Emissions of non-carbon dioxide gases;
- Information about "off-shored" emissions.

Users constantly request **timelier estimates of emissions**, and several NSOs have experience in nowcasting and improving timeliness of statistics. The Sponsorship Group on Measuring Progress, Well-being and Sustainable Development[31] identified the need to produce early estimates of CO_2 emissions based on monthly energy statistics, thus improving timeliness of indicators.

In some cases, the **length of time series** is not sufficient, for example for analysing the drivers of emissions. NSO plans to develop statistics on material flow accounts, environmental goods and services, taxes, protection expenditure and energy accounts may contribute positively to the work of inventory compilers.

The challenges of GHG inventories are reflected in the *Inventory Review Reports*. Analysis of these reports helps identify areas, where NSOs could contribute e.g. by improving availability and usefulness of source data for emission inventories. Amongst other things, inventory reviews consider accuracy of estimates, and frequently conclude that there is a need for quality improvements in particular sectors of inventories. The reports note that countries have made major improvements in the quality of emission inventories in recent years: better time series consistency, use of higher-tier estimation methods, use of country-specific estimation factors and more accurate activity data. Several reports refer to deficiencies in **waste data**, such as in the types of waste disposed, waste water output and handling. The quality and availability of time series data on **land use and forestry** requires further improvements in many countries. **Timeliness of activity data** was also mentioned as a problem in several countries. The **general areas of improvement for emissions inventories** can be summarized to the following five topics:

- **Source data**: availability, access to data, accuracy and timeliness of source data;
- **Quality of results**: completeness, level of detail, accuracy of results and consistency;
- **Communication**: transparency of methods used, documentation and archiving;
- **Methodology**: use of comparable methods, time series consistency and quality assurance procedures;
- **Organization and capacity**: descriptions of institutional arrangements and capacity of the national system.

Furthermore, NSOs are often **not aware of the data needs** of emission inventories and thus not prepared for responding to the data requirements stemming from the Kyoto Protocol. Data

[31] Final report of the Sponsorship Group on Measuring Progress, Well-being and Sustainable Development: epp.eurostat.ec.europa.eu/portal/page/portal/pgp_ess/0_DOCS/estat/SpG_Final_report_Progress_wellbeing_and_sustainable_deve.pdf

requirements for producing inventories should be made clear to NSOs. To assist with this, the United Kingdom has provided a table which sets out the key datasets against each of the inventory sectors (see Annex 4). This table can be used as a tool to find out what data NSOs could provide for emission inventories.

From the perspective of inventory compilers, the most obvious role of NSOs relates to national energy balances, which fall within the remit of a large number of NSOs. About 80 per cent of all GHG emissions are accounted for by energy combustion activities, and energy balances are, therefore, the most important input to the inventory submissions. The quality of reported GHG emissions heavily depends on the energy balance. The Task Force noted a particular interest in close cooperation among NSOs, energy agencies and inventory compilers to **improve energy data** and add clarity about which energy data feed into the inventory calculations and how.

2.4 Challenges with statistical infrastructure

Filling the above statistical gaps will challenge the infrastructure of statistical offices and require reviewing and partly changing the way NSOs work. On the other hand, it will allow current strengths of official statistics to better benefit the compilation of emission inventories.

There is no common definition of statistical infrastructure. The Australian Bureau of Statistics (ABS) defines statistical infrastructure as tools that support the operation of a statistical system. These tools can help to organize the statistical system, improve efficiency, add value, create new outputs or simply perform tasks within the system. Examples of statistical infrastructure include computer systems, metadata repositories, legislation, standards and classifications, frameworks and information development plans. Not all of these issues have specific relevance for compiling emission inventories. Therefore, the section focuses on the readiness of statistical systems in the following issues: legislation, standards and classifications, frameworks and integration, statistical methods and computer systems, organizational structures and production resources, quality assurance and guidelines, knowledge and cooperation networks.

The **methodological advantages** offered by the NSO infrastructure to the compilation of greenhouse gas inventories could include: close collaboration with energy statistics and other source statistics; access to confidential source data, e.g. on waste, industrial production and environment; experience on improving timeliness; better consistency with official statistics; high level of transparency through metadata and archiving; use of internationally comparable methods and well-developed quality assurance methods.

There are several challenges related to the shortcomings of statistical infrastructure with regard to supporting the production of GHG inventories. According to the UNECE survey, such challenges include confidentiality issues, lack of capacity and knowledge of data needs, database management resources, data coherence and challenges in cooperation between involved agencies.

This section analyses the parts of the infrastructure that are weakest or missing with regard to the requirements of GHG inventories, and highlights some of the important strengths too. It aims to identify the key adaptations needed in the current statistical systems to improve the ability to respond to the information needs of emission inventories.

LEGISLATION

Legislation has a crucial role in supporting the production of emission inventories. Without unambiguous legislation, unclear division of work between organizations may overly complicate compilation of GHG inventories.

Legislation should, therefore, **facilitate effective cooperation** between agencies and grant the possibility to **exchange the required data**. The legislation dealing with GHG inventories should be in line with the national statistical law and the related articles on confidentiality. The quality of

emission inventories could be enhanced if those outside the statistical system responsible for the calculations were permitted access to official statistics at the unit level. As this is often not possible because of restrictions on access established in national statistical laws, some countries assign responsibility for part of the calculations directly to NSOs. Another option, which has not yet been tried anywhere, would be to consider inventory compilers as part of the official statistical system to facilitate access to the required data; this would obviously require their adherence to the legal requirements of the national statistical law.

Ideally, national legislation **providing for the right to collect and access data** needed for emission inventory compilation would exist in all countries. Though such legislation does exist for the production of official statistics (national statistical laws), it does not always exist for emission inventories. In the EU, the recently adopted Monitoring Mechanism Regulation[32] stipulates that "Member States shall ensure that their competent inventory authorities have access to" :

- data and methods reported for activities and installations;
- where relevant, data collected through reporting systems on fluorinated gases;
- where relevant, emissions, underlying data and methodologies.

STANDARDS AND CLASSIFICATIONS

One of the most common problems encountered by many countries is the **mismatch between the reporting classifications** for GHG inventories as defined by the Intergovernmental Panel on Climate Change (IPCC) compared with international statistical classifications. This represents a major obstacle for analysing and linking the data with official statistics for example, to facilitate better use of energy statistics in the compilation of GHG inventories. The mismatch complicates matters in two ways: to use NSO data for GHG compilation and for NSOs to reuse the GHG inventory results combination with other related data. In some areas, this leads to duplication of efforts and parallel data collection.

The data of the GHG inventories are reported to the UNFCCC according to the Common Reporting Format (CRF) framework, which uses a classification developed by the IPCC. The CRF framework encompasses the different sources and sinks of greenhouse gas emissions arising from human activity, grouping them in sectors. Each sector generally reflects a certain type of emission source (or sink) from a technological viewpoint; for example, combustion of fossil fuels, regardless of where this combustion occurs (on the national territory) falls under the sector "energy", which includes combustion in industry, transport, energy transformation, refineries, etc. From the viewpoint of national statistics, the IPCC sectors are, in fact, a combination of what are normally considered industries (e.g., electric power generation) and what are considered activities based on both economic processes (e.g., transportation) and on products (e.g., solvents).

[32] Monitoring Mechanism Regulation[32] (Regulation (EU) 525/3013), Article 5(2): eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:165:0013:0040:EN:PDF

The current source/sink sectors[33] in the IPCC Common Reporting Format (CRF) are the following:[34]

1	Energy sector
2	Industrial processes
3	Solvents and other products use
4	Agriculture
5	Land use, land use change and forestry (LULUCF)
6	Waste management
7	Other sector

In GHG inventories, the meaning of **energy sector** is different from the ISIC-class D (electricity, gas, steam and air conditioning supply) that is used in official statistics, even though they are both called the "energy sector" in everyday speech.

In GHG inventories, the sector **agriculture** includes emissions connected to agricultural processes: enteric fermentation, manure management, rice cultivation, cultivation and management of agricultural soils etc., but not emissions of the energy use in agriculture.

The sector on **land use change and forestry** contains the emissions caused by changes in land cover and CO_2 -emissions from soil, including agricultural soil. Other greenhouse gases from agricultural soil are included in agriculture sector.

The CRF sectors do not permit easy linking of inventory data with statistics compiled by NSOs so that emissions may be allocated to industries as defined in official statistics. The CRF sectors are well suited to the scientific and technical monitoring of emissions, but they do not generally reflect social and economic considerations. Because of their differences with statistical classifications, the CRF sectors do not allow easy analysis of the role of households or industries in climate change or the costs of limiting emissions. For instance, a common question the media is asking is households' share of total emissions. To this question, the CRF tables do not give a straightforward answer.

The *Manual for Air Emissions Accounts*[35] presents a general procedure for the 'inventory-first approach' where emission inventory data are assigned to economic activities (ISIC/NACE) and households' activities. The manual provides a correspondence table between the Selected Nomenclature for Air Pollution (SNAP97), CRF and NACE rev.2 which may be useful for linking between CRF and the economic activity classification.

FRAMEWORKS AND INTEGRATION

Reviewing links between different statistical frameworks that include data relevant for GHG inventories can help identify potential synergies and prevent creation of duplicate data collections. Important synergies could exist, for example, between the GHG inventories and energy statistics, national accounts, environmental accounts, air emissions accounts and the System of Environmental-Economic Accounting (SEEA). The links to SEEA and the Framework for the

[33] The source/sink sectors as defined by the Intergovernmental Panel on Climate Change (IPCC) in the *Revised 1996 Guidelines for national greenhouse gas inventories* www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

[34] The manual for Air Emissions Accounts: epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-004/EN/KS-RA-09-004-EN.PDF

Development of Environment Statistics (FDES) were discussed in Chapter 1. Greater involvement of NSOs in national GHG inventory systems would help ensure better consistency of the inventories and the various statistical frameworks discussed next.

A key tool in the verification of emission estimates in the energy sector is the IPCC Reference Approach, which is also an independent method for estimating CO_2 emissions as a cross-check to the GHG inventory results. The method uses data from **national energy balances**[36]. Ideally, there should not be significant differences between CO2 emission estimates reported in the GHG inventory and estimates based on the national energy balances. If the difference between the two approaches is more than 2 per cent, parties are required to provide clear explanations in the GHG inventory report. At European level, the EU Energy Statistics Regulation explicitly requires Member States to ensure the consistency of activity data reported to UNFCCC with the energy balances reported to Eurostat.

A good example of the capacity of national statistical offices to link statistical data and compile timely statistics, is the quarterly estimate of CO2 emissions produced by Statistics Netherlands at a lag of 45 days. Though much less detailed than the Dutch GHG inventory, these statistics are much timelier – GHG inventories usually become available about nine months after the end of the year under review. Additional data collection is not needed for the quarterly estimate as data are derived from monthly energy statistics, quarterly national accounts and other existing sources.

Environmental-economic accounts are satellite accounts to the national accounts that provide information on the relationship between the economy and the environment. They enable, for example, comparison of the amount of carbon dioxide emitted per a unit of value added in countries. As they are internationally standardised, environmental accounts allow for comparison between countries and time. Environmental-economic accounts include for example air emissions accounts, environmentally related taxes by economic activity and material flow accounts. In all these modules, the statistical data are presented according to the International Standard Industrial Classification (ISIC/NACE). The direct usability of GHG data in environmental accounts is limited because of the crucial difference in classifications as described above. For some countries, it is a question of two parallel systems, which have very limited synergies. Usually the accounts are compiled by NSOs and GHG inventories by other agencies. In those countries, where the GHG inventory is compiled using the national energy balances, synergies could be found among the GHG inventory, environmental accounting and energy statistics.

The different geographical coverage of emission inventories and **air emissions accounts** also poses challenges. The air emission accounts, produced by NSOs, include (1) residents of the national territory and (2) units operating abroad (rest of the world). GHG inventories combine the first category with non-resident units that impact the national territory. The main differences caused are reflected in the area of land, water and air transport and national fishing vessels operating abroad.

STATISTICAL METHODS

The UNFCCC and IPCC reporting guidelines form an information framework for the GHG inventory data. The quality of source data for emission inventories could benefit from statisticians having a better **understanding of the concepts and methods used in inventory compilation**. This would help ensure that statistics are established in such a way that they can be easily used for emission inventories.

The Conference of Parties (COP) has developed standardized requirements for reporting national inventories. The UNFCCC inventory reporting guidelines are currently based on the methodologies

[36]The estimate is based on apparent consumption which refers to the balance of primary fuels produced in a country, plus imports, minus exports, minus international bunkers and the net change in stocks, adding also the apparent consumption of secondary fuels.

and reporting formats of *the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*[37]. Furthermore, *the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, complements the 1996 guidelines. In 2004, separate *IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry* was developed.

At the moment, IPCC is working to develop and maintain the methodological guidelines for emission inventories. The first draft of *the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*[38] has been reviewed by experts. New *2006 IPCC Guidelines for National Greenhouse Gas Inventories*[39] will also be applied as of 2015. These may require changes in the inventory source data. NSOs may not yet be aware of **the specific changes in methodology and data requirements**. It might be beneficial to involve them e.g. to assess data availability and feasibility of requirements, and to enable NSOs to prepare themselves for the new or changed requirements.

If statistical offices are not involved in compiling emission inventories, they are often not aware of the specific methodological guidelines targeted to emission inventory compilers or the related inconsistencies with official statistics. Furthermore, NSOs do not routinely follow up on changes in **data requirements stemming from the Kyoto Protocol**, in spite of the implications these have for compiling activity data. For example, the new *2006 IPCC Guidelines* just noted, may change some of the statistical needs behind inventories. Ideally, NSOs would be informed of such upcoming statistical needs through cooperation with the national entity responsible for inventories.

ORGANIZATIONAL STRUCTURES AND PRODUCTION RESOURCES

The activity data for GHG inventories is normally distributed across several organizational units within NSOs. Those offices that take part in the calculations of emission inventories have a specific organizational unit that has been assigned tasks related to emission inventories. In other offices, the **counterpart for inventory compilers** is often missing from the side of NSOs.

As mentioned earlier, existing official statistics are not used to their full potential for emission inventories. Parallel and sometimes **duplicate reporting** exists; for example, energy data are reported both in energy statistics and in emission inventories. This leads to unnecessarily **high costs** of data collection and **additional burden for respondents**.

QUALITY ASSURANCE AND GUIDELINES

Different quality reviewing procedures guide the production of GHG inventories and official statistics. The European Statistical System (ESS) Code of Practice[40] provides practical quality assurance guidelines in line with the Fundamental Principles of Official Statistics. The Code of Practice is based on 15 Principles covering (1) the institutional environment, (2) the statistical processes and (3) the output of statistics. A set of indicators of good practice for each of the Principles provides a reference for reviewing the implementation of the Code. The quality criteria for European Statistics are also defined in European Statistical Law.

Perhaps the most important difference in the quality frameworks of official statistics and GHG inventories concerns the **institutional framework of data production**. For this area, the ESS Code of Practice includes standards for professional independence, mandate for data collection, adequacy of resources, quality commitment, statistical confidentiality, impartiality and objectivity. Of the above

[37] The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: www.ipcc-nggip.iges.or.jp/public/gl/invs6.html

[38] The 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol: www.ipcc-nggip.iges.or.jp/home/2013KPSupplementaryGuidance_inv.html

[39] The 2006 IPCC Guidelines for National Greenhouse Gas Inventories: www.ipcc-nggip.iges.or.jp/public/2006gl/

[40] The European Statistics Code of Practice: epp.eurostat.ec.europa.eu/portal/page/portal/quality/documents/CoP_October_2011.pdf

criteria, the UNFCCC reporting guidelines only mention confidentiality, but not for example independence or mandate for data collection.

In the area of statistical processes, the Code of Practice gives recommendations on sound methodology, appropriate statistical procedures, non-excessive burden on respondents and cost-effectiveness. For the GHG inventories, the UNFCCC reporting guidelines and the *IPCC Guidelines for National Greenhouse Gas Inventories* lay down the methodological instructions for producers. These do not explicitly consider **burden on respondents or cost-effectiveness**.

Important differences also exist in the **treatment of confidential data**. The UNFCCC reporting guidelines state that "emissions and removals should be reported at the most disaggregated level of each source/sink category, taking into account that a minimum level of aggregation may be required to protect confidential business and military information." Safeguarding the confidentiality of data is crucial for the reliability of official statistics. Therefore, NSOs cannot publish company-specific information, unlike emission inventory compilers.

There are also **many similarities in the quality criteria** used for the results of GHG inventories with the Fundamental Principles and the Code of Practice that deal with statistical output. The quality standards of statistical outputs require relevance; accuracy and reliability; timeliness and punctuality; coherence and comparability; and accessibility and clarity. The UNFCCC reporting guidelines suggest similar criteria for the annual GHG inventories including transparency, consistency, comparability, completeness and accuracy[41]. The practice, however, differs more than the names of the quality aspects. The descriptions of the quality criteria for official statistics and GHG inventories are provided in Annex 5.

A process of peer reviews is carried out before publishing the results of GHG inventories. The reviewers get **access** to the inventory results before their publication. The reviews are guided by *the UNFCCC guidelines for the technical review of GHG inventories*[42]and *a code of practice for the treatment of confidential data*[43]. In official statistics results are not shared with third parties before they become public to everyone. Instead, according to the principle of impartiality and objectivity, all users have equal access to statistical releases at the same time.

The most important quality aspect for the review of information reported to UNFCCC is **transparency**, as lack of it impairs the assessment of the remaining quality criteria. In the lack of quality criteria for the institutional environment, the transparency criterion becomes fundamental. Similar issues are covered under the accessibility and clarity criterion of the ESS Code of Practice. The Code of Practice underlines more clearly the need to present statistics in a clear and understandable form, but on the other hand, the UNFCCC reporting guidelines suggest a specific format for data reporting.

Another practical difference exists in the area of **accuracy** of results. Emissions are not exact because the emission factors need to be estimated. To this end, inventories may be considered as being closer to science than official statistics. The GHG inventory producers often talk about reducing uncertainties as a tool for improving the accuracy of estimates.

In 2008, the quality gaps of GHG inventories led to launching an approach called "measurable, reportable and verifiable" as part of the Bali Action Plan. Nowadays, the approach is more often called **monitoring, reporting and verification** (MRV). Monitoring refers to collecting the relevant information to measure whether the country is on track with regard to its emission targets. Reporting refers to the commitment by parties to the UNFCCC to report progress on climate related activities via national communications. Verification aims to ensure that the reported information is

[41] Updated UNFCCC reporting guidelines on annual inventories: unfccc.int/resource/docs/2006/sbsta/eng/09.pdf
[42] Review process: unfccc.int/national_reports/annex_i_ghg_inventories/review_process/items/2762.php
[43] UNFCCC Code of practice for the treatment of confidential information: unfccc.int/files/national_reports/annex_i_ghg_inventories/application/pdf/ext_cp0306a1.pdf

correct and that confirmed methodologies have been used. All parties to the UNFCCC have agreed to enhance their national MRV systems, but especially many developing countries have challenges in ensuring the quality of their data. NSOs could contribute to the monitoring and verification of the activity data and the methodology underpinning emission estimates. The data collected by NSOs could be used as a verification and quality assurance tool for the GHG inventories.

To facilitate access to the required data and closer cooperation in data quality issues, some have considered **whether emission inventory compilers could be part of the official statistical system**. Inventory compilers may consider emission inventories already as "official" since they are called "official communications". Consideration as "official" in the statistical system's use of the term would, however, require adherence to somewhat different standards than the current criteria guiding the compilation of GHG inventories.

KNOWLEDGE AND CAPACITY

Given that the statistical system holds a lot of data with relevance to emission inventory compilation, official statisticians' **knowledge of the GHG inventory data needs** should be improved. That would enable reviewing and reorganizing the existing data of NSOs to match the source data needs of emission inventories.

NSO **expertise in activity data** could help in cases of problems in data quality, data usefulness or consistency.

NSOs are in a good position to support emission inventory compilation by **making use of the many detailed data sources** they have, and their knowledge of statistical production methodology. For instance, NSOs have developed methods to allow compilation of very timely estimates, such as flash estimates of gross domestic product (GDP) or short-term statistics. These methods could be used to help improve timeliness of GHG emissions data; the quarterly emission estimate of Statistics Netherlands is a good example of the possible contribution NSOs could offer.

NSOs could also **share experience** across countries on how they take part in the emission inventory process. This could save resources and mutual support among countries would be helpful for capacity development. NSOs also have **an international network for statistical development** and sharing of experience. In this context, it is worth noting that all countries that are party to the next international climate convention will need to have approved national inventories of good quality that are suitable for monitoring developments in emissions. The 17th UNFCCC Conference of the Parties in Durban agreed to a major change to be implemented from 2020 in which all countries will be required to submit annual inventories. There is, therefore, an important opportunity in the next few years to make use of NSOs knowledge and experience in capacity building in new countries that will be obliged to compile GHG inventories.

COOPERATION NETWORKS

Closer cooperation between NSOs and inventory compilers has the potential to be mutually beneficial, since GHG inventories rely on the NSO data and the NSOs often take the results of GHG inventories once published and adjust them to national accounts concepts to allocate emissions to industries and households. The latter is actually a requirement in Europe through the EU Regulation on European environmental accounts that was adopted in 2011.

The quality of emission inventories would benefit from an institutionalized data collection and compilation system and a clear division of responsibilities. In the UNECE survey, several countries mentioned having some challenges in cooperation with the GHG inventory compilers. Many of the shortcomings of the inventory system relate to institutional arrangements in the infrastructure of the national system of GHG inventories. NSOs are not always actively involved in the work, which is why they cannot offer their competences in support of **the quality of inventories.** Therefore, their

data are not used to the full extent. This also partly explains why the **links between inventories and other statistics** are often weak.

Meeting the data needs of GHG inventories requires cooperation throughout the statistical system. For example, the role of statistical offices in the compilation of GHG inventories is not always clearly defined, yet it can be important for the activity data. **Greater interaction** between statistical offices, inventory compilers and environmental and energy agencies needs to be established in order to find synergies.

International cooperation between the statistical community, UNFCCC and IPCC should be improved. Existing official statistics might be made more useful for emission inventories if the statistical community were consulted by the IPCC and UNFCCC when drafting data requirements. This could help reduce the costs of the global system and improve the quality of inventories. The statistical community should also follow up on the outcomes of the UNFCCC Conferences of the Parties, in particular those related to the MRV system. The statistical community can add value also by assessing data availability and feasibility.

2.5 Conclusions on greenhouse gas inventories and official statistics

1. The statistical system continuously adapts itself and its tools to provide relevant information. The statistics used as the basis for the GHG inventories need to be examined to **determine if the current statistics adequately cover the data needs or** whether there are missing areas to be incorporated into the regular statistical production systems. It is currently not clear to all NSOs which data are required for the compilation of greenhouse gas inventories, and specifically which datasets are likely to be sourced from official statistics. The Task Force has, therefore, put together a table that NSOs can use to track which data could be sourced from the national statistical system (see Annex 4). Information on what data are needed would help NSOs to better organize their work and optimize the data for the purposes of emission inventories.

2. **Legislation** has a crucial role in supporting production of emission inventories and cooperation among agencies. National legislation should facilitate effective cooperation between agencies belonging to the national emission inventory system and provide a legal basis for exchange of data as required for the inventories.

3. The statistical system should **be more engaged in the methodology development** led by the IPCC so that the new methods take into account existing statistics and the underlying methodology. Experts from the statistical offices can be helpful in evaluating if the needed source data in a proposed methodology are available or possible to develop within reasonable costs. Methodology development needs to be based on what is realistically available and does not impose unreasonably high costs on inventory compilers, statistical systems or respondents.

4. The statistical system needs to be involved in discussions regarding **data quality** so they can focus on important improvements in the activity data. The IPCC regularly analyses the quality of the countries' inventories, and NSOs should look closely at the *Inventory Review Reports* to see if there are improvements needed in the basic statistics or the way they are used. The statistical data used to build the inventories should be considered part of the core of NSOs' work on climate change related statistics. NSOs can always initiate these quality improvements for the data falling within their mandate. NSOs could also have a wider role to play in the area of quality assurance of GHG inventories even in areas where their data are not used. This could, in fact, be a natural entry point to increased involvement by NSOs in GHG inventories. In the UNECE survey, the majority of NSOs thought it would be beneficial to discuss how the UNFCCC Measurement, Reporting and Verification (MRV) approach to inventory compilation applies to the work of NSOs.

5. Whereas a more active role of NSOs would support the quality of GHG inventories, the **delicate negotiation process** of the Kyoto protocol needs to be respected. NSOs should, therefore, rely on existing guiding frameworks for GHG inventories rather than expecting many changes. However, NSOs would need to follow-up on upcoming changes in data requirements, especially concerning activity data, energy statistics and energy balances.

6. It is unlikely that the methodological or classification differences between GHG inventories and official statistics would be changed in the short term. Yet, they increase the workload as inventory compilers need to reclassify and recompile existing data, and in some cases similar data needs to be collected twice. Statisticians, therefore, need to try to find some solutions to create **links between inventories and other statistics** through mapping of standards and classifications or through closer cooperation in the allocation of emissions. This would enable analysts to undertake integrated analysis of the economic, social and environmental aspects of GHG emissions. Emission inventories have especially important links with the system of national accounts, environmental accounting, air emissions and energy statistics.

7. NSOs could also work with inventory compilers to make activity data available at an earlier stage to help develop **timelier emission estimates** as opposed to current two year lag, or they could develop early estimates of GHG emissions using monthly and quarterly data sources that would not be comprehensive enough for actual GHG inventories. This would help more effectively inform climate change mitigation polices.

8. NSOs can also support the analysis of emission trends by providing background **socio-economic data**. Some examples of such data include population, fuel prices, GDP and gross value added (GVA) by branch, national energy balances, and heating/cooling degree days. In particular, NSOs are well placed to contribute to analysing emissions by economic sectors.

9. The overwhelming conclusion drawn from the evidence available to the Task Force is that there is a clear need for **greater involvement of NSOs** in emission inventory compilation. The benefits to the inventory process will be that this makes greater use of the knowledge NSOs have of the underlying datasets, whilst also benefiting from the high public trust afforded to NSOs as professionally independent producers of statistics. This would help reduce parallel and sometimes duplicating reporting systems and unnecessarily high costs of data collection and respondent burden. For this purpose, NSOs should have a contact person who would be in charge of coordinating GHG inventory source data issues, collaborating with the inventory compilers and keeping up with the outcomes of the UNFCCC conferences of the parties to better understand and prepare for the associated data requirements.

10. Closer **cooperation is needed at international level** too. The possibilities to improve the relationships between the concepts and classifications should be examined at the international level. To be consulted in the methodology development, NSOs would have to be represented by an international organization, such as the United Nations Statistical Commission, in order to liaise with the UNFCCC and IPCC.

11. The Task Force acknowledged the need for **capacity building** especially, but not only, in countries who have not yet produced annual GHG inventories. All NSOs who are not currently involved in their country's inventory compilation need to improve their knowledge on the topic. There are currently no **recognized good practices** for NSO role in GHG inventory compilation, but it would be in the interest of both NSOs and inventory compilers to consider what they would actually be.

3 CLIMATE CHANGE RELATED STATISTICS OTHER THAN THOSE RELATED TO GHG INVENTORIES

Chapter 1 defined the scope of climate change related statistics to include *environmental, social and economic data that measure:*

1. **Greenhouse gas emissions**: the part of *human causes of climate change* that deals with emissions directly,
2. **Drivers**: the part of *human causes of climate change* that deals with sources and causes of emissions,
3. **Impacts:** *impacts of climate change on human and natural systems,*
4. **Mitigation:** *efforts of humans to avoid the consequences,*
5. **Adaptation:** *efforts to adapt to these consequences*.

Statistics related to greenhouse gas (GHG) inventories were discussed in Chapter 2. This chapter focuses on the remaining groups of climate change related statistics (2 to 5 of the above list).

This chapter explores users' needs for climate change data in both the scientific and policy communities and reviews existing statistics and involvement of national statistical offices (NSOs) with the aim to identify which of those needs that are currently unmet could be met by NSOs.

Whereas a well-established reporting process exists for GHG inventories, information on other aspects of climate change, including on its social and economic impacts as well as mitigation and adaptation efforts, is less well developed. National statistical systems have a largely unused comparative advantage in the area, namely their possibility to access large and diverse microdata sets and combine various types of environmental, social and economic data relevant for climate change analysis. The chapter covers data needs that users express now, but considers also the future needs that users may not know yet.

The chapter discusses which needs for climate change related data NSOs would be able to meet, and how to improve the availability and usefulness of official statistics to better meet these needs.

3.1 User needs for climate change related statistics

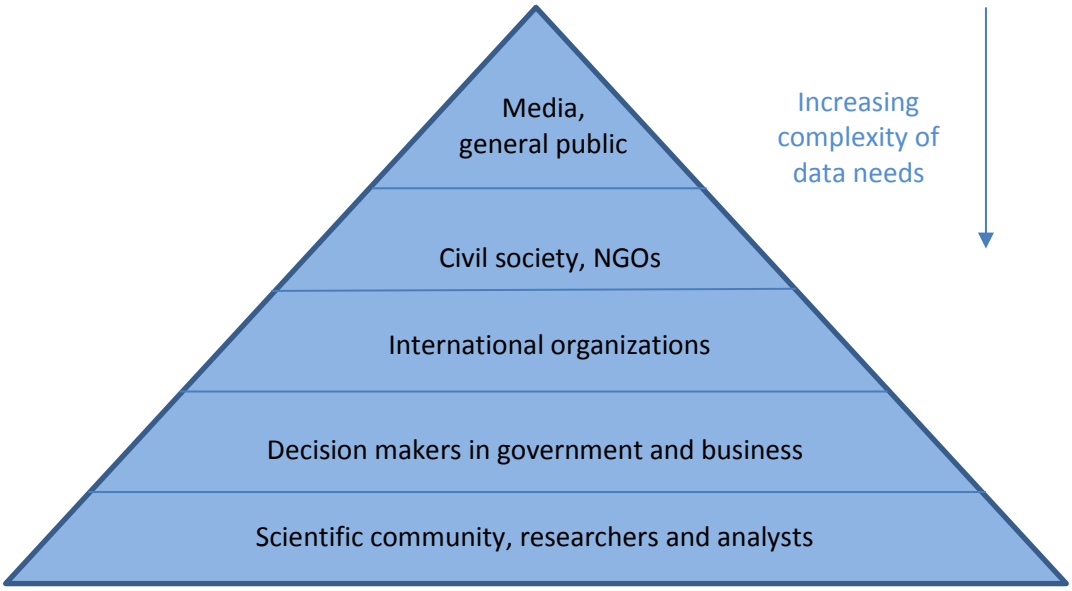
The United Nations Conferences on Climate Change Statistics in Oslo[44] and Seoul[45] in 2008, reflected awareness of the official statistical community of the need to consider climate change as a statistical topic. The Conferences emphasised the need to better understand the data requirements of stakeholders. The Task Force carried out some stakeholder interviews and analysed the outcomes of recent meetings and policy documents related to climate change.

The different user groups interested in climate change related data are illustrated in Figure 3. In the triangle, the data needs get more complicated and specialised towards the bottom of the triangle. The scientific community and analysts require access to detailed data. Since climate change cannot be meaningfully observed from one year to the next, these users require both long time series and frequent sampling. Decision makers may require complex data, but usually in the form of answers to their policy questions. International organizations often collect existing statistics for their analytical work, and the civil society and NGOs to monitor and assess developments in their interest area. Going up the triangle, the media and the public often require information that is easy to digest. All users require timely, accurate and reliable information.

[44] Conference on Climate Change and Official Statistics, Oslo: unstats.un.org/unsd/climate_change/default.htm

[45] Conference on Climate Change , Seoul: unstats.un.org/unsd/climate_change/korea/

Figure 3: Grouping of the users of climate change related statistics, other than GHG inventories.



One can say that there are users (1) who know what they want; (2) those who need guidance in identifying which data they need; and (3) those who do not have precise requirements; for example the general public, who want basic information that is easy to use and understand. NSOs need different approaches for communication with the different user categories. Perhaps the most difficult user needs to satisfy are those of policy makers who need answers rather than datasets. The following case study gives an example of the types of challenging societal phenomena policy makers need to monitor with reliable information.

Case study: European Environment Agency (EEA): policy data needs for monitoring megatrends in Europe.

MOST OF THE EUROPEAN MEGATRENDS HAVE A LINK TO CLIMATE CHANGE

The State of the Environment Report *2010 – Assessment of global megatrends*[46] focuses on the impact of major global trends on Europe. The assessment provides detailed analysis of social, technological, economic, environmental and political megatrends, and considers their links with Europe's environmental challenges and policy implications. The megatrends reflect priority policy areas on which reliable information is needed. Surprisingly many megatrends mentioned on the list have a connection to climate change:

- Increasing divergence in population trends: populations ageing, growing and migrating;
- Living in an urban world: spreading cities and spiralling consumption;
- Changing patterns of global disease burdens and the risk of new pandemics;
- Accelerating technologies: racing into the unknown;
- Continued economic growth?;
- Global power shifts: from a unipolar to a multi-polar world;
- Intensified global competition for resources;
- Decreasing stocks of natural resources;
- Increasing severity of the consequences of climate change;
- Increasingly unsustainable environmental pollution loads;
- Global regulation and governance: increasing fragmentation, but converging outcomes.

The following section looks at data needs grouped into drivers, impacts, mitigation and adaptation according to the groups of statistics belonging to the scope of climate change related statistics.

[46] European Environment Agency: The European environment state and outlook 2010: synthesis: www.eea.europa.eu/soer/europe-and-the-world/megatrends

DRIVERS

Users need basic statistical data to analyse the underlying human drivers leading to GHG emissions and climate change. Here we exclude data needs related directly to monitoring GHG emissions as they have been discussed in Chapter 2. Relevant statistics, as listed in Chapter 1 for driving forces and pressures of climate change include among others: population, urbanization, consumption, energy, transport, housing, waste, land use, agriculture, economy (GDP), industry, internationalisation and tourism. Some of these areas are the same as for GHG emission inventories. This chapter considers these areas from the viewpoint of general pressure on the environment, not as sources of the GHG emissions.

Users are interested for example in the contribution of energy-intensive economic sectors to GDP, exports and imports. Energy consumption by human activities that can directly release heat into the environment is of interest, including data on heating buildings, powering electrical appliances and fuel combustion by vehicles.

Statistics on drivers are typically available from statistical offices. However, users need to be able to better **link these statistics with climate observations** to better analyse them. There is clearly need for better access to these data: the meeting of the Climate Observation Community, in December 2011, underlined the "need to establish mechanisms for connecting climate data and socio-economic data, including accessibility to the latter data. It is noted that socio-economic data exists but it is generally not known within climate communities. "[47]

The analysis of drivers sometimes requires **access to microdata**. Researchers can be a useful additional resource for analysing and exploiting data held by NSOs. In many countries, access to microdata by researchers is limited due to confidentiality requirements. Procedures exist to permit this access, but they can involve complex application procedures and knowledge of the rules governing different datasets and producers. Several NSOs are developing new tools for improved access to microdata, while respecting the need to safeguard confidentiality. In general, researchers are likely to be more interested in finding answers to research questions than in access to microdata for its own sake. Therefore, interesting solutions may be found in terms of remote access where the user only receives the aggregated results of his/her queries to the data. For example, Australia[48] is developing *Remote Analysis Servers (RASs)* and the US Census Bureau[49] a *Microdata Analysis System* for researchers to perform certain statistical analysis without direct access to microdata. Finland[50] is working towards a national system for microdata access that would bring together datasets of different agencies via one web portal. In Canada, access to economic microdata is being facilitated through Statistics Canada's *Centre for Data Development and Economic Research.*[51]

IMPACTS

A great deal of scientific information about the biophysical changes in the climate exists, for example in the assessment reports of the Intergovernmental Panel on Climate Change (IPCC). These assessments make use of environmental data and statistics. Analysis of the other side of impacts, the socio-economic consequences – such as economic losses and gains, access to food and water, poverty and migration – is still less developed in climate literature. This seems to be partly because

[47] Report of the meeting of the Climate Observation Community: www.wmo.int/pages/prog/wcp/wcdmp/documents/obs_mon_outcomes.pdf

[48] Innovative micro-data access - confidentiality on the fly, by the Australian Bureau of Statistics: www.unece.org/fileadmin/DAM/stats/documents/ece/ces/2013/29.pdf

[49] The Microdata Analysis System at the U.S. Census Bureau: www.amstat.org/sections/srms/proceedings/y2011/Files/302160_67955.pdf

[50] Development and challenges of on-line micro-data usage, by Statistics Finland: www.unece.org/fileadmin/DAM/stats/documents/ece/ces/2013/33.pdf

[51] Statistics Canada's Centre for Data Development and Economic Research: www.statcan.gc.ca/cder-cdre/index-eng.htm.

of the difficulty to define cause-effect relations, and partly because of lack of sufficiently detailed data. While NSOs should not make judgements about cause-effect relations, they should improve availability of useful data for doing so. Users need data at least on the impacts on:

- Environment;
- Housing, social conditions and social equity, poverty;
- Access to services and resources;
- Health status: impacts from heat waves, extreme weather, reduced air quality, climate-sensitive diseases etc.;
- Costs and benefits of climate change for industry, settlement and society;
- Consequences of extreme events (including costs).

The following case study provides an example of actual impact indicators used to monitor climate change in California. The lack of indicators on the costs and benefits of the impacts of climate change and on is social impacts underlines the current difficulty to link socio-economic data with climate observations.

Case study: Indicators on the impacts of climate change in California.

CLIMATE CHANGE IMPACT INDICATORS IN CALIFORNIA

The 2013 edition of the *Indicators of Climate Change in California* tracks trends in GHG levels that influence climate, changes in the state's climate, and the impacts of climate change on California's environment and people. This Table provides a list of currently used impact indicators. These indicators rely on monitoring and research activities carried out by state and federal agencies, universities, and other research institutions.

Physical systems	Humans	Vegetation	Animals
Annual Sierra Nevada snowmelt runoff; Snow-water content	Mosquito-borne diseases	Tree mortality	Migratory bird arrivals
Glacier change	Heat-related mortality and morbidity	Large wildfires	Small mammal range shifts
Sea level rise	Exposure to urban heat islands	Forest vegetation patterns	Spring flight of Central Valley butterflies
Lake water, delta water and coastal ocean temperature		Subalpine forest density	Effects of ocean acidification on marine organisms
Oxygen concentrations in the California Current		Vegetation distribution shifts	Copepod populations
		Alpine and subalpine plant changes	Sacramento fall run Chinook salmon abundance
		Wine grape bloom	Cassin's auklet populations; Shearwater and auklet populations off Southern California
			Sea lion pup mortality and coastal strandings

MITIGATION

In practice, mitigation policies aim at reducing GHG emissions, increasing carbon sinks for example through reforestation, switching to renewable energy sources and improving energy efficiency. The more specific indicators and variables that feed the process of integrated climate-economic analysis vary according to the specific needs of users. However, more generally analysis of mitigation looks at the **use of mitigation measures and their effectiveness**, e.g. use of economic instruments, such as

subsidies and taxes, as well as investment into green technology, or the use of regulatory schemes (e.g. "cap-and-trade" systems, such as the EU Emissions Trading System) and other measures for emissions abatement. The following is a non-exhaustive list of examples of data needed:

- Subsidies, for example for green technologies or fossil fuels;
- Turnover and employment of the "green" sectors, e.g. the renewable energy technology industries, electric vehicles, recycling, etc.;
- New investment in "green" jobs and sectors and in renewable energy;
- Research and development: financing of research and development related to "green" sectors or climate mitigation;
- Energy efficiency: energy use per unit of human activity;
- Fuel mix: use of renewable energy sources (solar, wind, hydro, geothermal and biomass energy);
- Ratio of emissions to turnover/gross value added for economic sectors to assess the greatest growth potential in relation to the emission abatement potential;
- Taxes: environmental taxes, including energy, transport, pollution and resource taxes;
- Environmental protection expenditure for climate-related activities, for example the costs of fighting coastal erosion;
- Financial statistics, for example financial support and level of technology transfer to developing countries, carbon taxes, tradable emission permits, and other financing mechanisms to mitigate climate change;
- Quantifiable effects of regulatory measures (e.g. in the European Union (EU), reduction of emissions in the EU Emission Trading System (ETS) or number of vehicles compliant with new standards for emission performance[52], etc.);
- Carbon capture and storage: separating, capturing and storing carbon dioxide from industrial and energy-related sources;
- Land use management: reducing and avoiding deforestation, forest management and restoration, afforestation and reforestation.

Data on traded emission reduction units (those of the emission trading schemes of the European Union and Australia) are an example of the type of mitigation data currently recorded in national registries and monitored by the United Nations Framework Convention on Climate Change (UNFCCC) under the International Transactions Log (ITL). Concerning NSOs, reliable data on the use of economic instruments will be needed as part of government finance statistics and national accounts, as mentioned in the above list.

The EU Commission has expressed the need for better data on mitigation of climate change, and supported in particular development of air emission accounts and data on environmental protection expenditure.[53] Indicators have also been developed for the monitoring of the Europe 2020 Strategy as illustrated by the next case study.

Case study: EU mitigation indicators developed for policy assessment.

EUROPE 2020 – MITIGATION INDICATORS

EU's growth strategy, Europe 2020, includes a so called Climate and Energy Package with ambitious targets for 2020. The three targets, known as "20-20-20", set by EU leaders in 2007, comprise:

- 20% reduction in EU greenhouse gas emissions from 1990 levels;

[52] For example, in the European Union there is legislation limiting the CO_2 emissions from new passenger cars and light-duty vehicles. Similar emission limitation or fuel economy standards exist in other countries (some may be voluntary), such as Japan, etc.

[53] *Climate change and European Official Statistics,* by Cesare Constantino and Angelica Tudini in Statistika Vol. 93 (2) 2013

- 20% of energy from renewable resources;
- 20% increase in energy efficiency.

The data needs related to the climate and energy package are linked to the implementation of the specific legal instruments that concern the EU climate policy, most notably the EU Emissions Trading System (ETS) with more than 11000 power stations and airlines trading with emission allowances and the Effort Sharing Decision which sets binding annual GHG targets for member states.

ADAPTATION

National adaptation strategies aim to raise the level of preparedness regarding any **population, industries or regions at risk** for future impacts of climate change. The strategies require a complex set of information. Adaptation indicators are often divided to:

1. Process-based indicators for monitoring progress in implementing adaptation measures; and
2. Outcome-based indicators for measuring the effectiveness of adaptation policies and activities.

Besides knowing what biophysical impacts to expect (e.g. floods, droughts, heat-waves, reduced rainfall, rising sea levels, disappearing glaciers, etc.), policy makers need to know which regions and communities those will affect – i.e. agricultural lands, with key infrastructure (ports, airports, transportation networks), residential, industrial plants, lands with dense population, coastal areas, mountain areas, etc. This means that demand for socio-economic information linked to location is growing quickly in most countries.

For this purpose, data on vulnerable industries and population need to be attributed to **different geographic regions** than usually provided by NSOs. Interesting regions include high risk areas, such as coastal and riverine areas and regions prone to extreme weather events. Providing more information related to urban areas will become more important, especially in developing countries. Economic sectors that depend on climate-sensitive resources, such as certain agricultural and forest industries, water demands and tourism, are of particular interest.

Adaptation policies need data for monitoring vulnerabilities of industry, infrastructures, settlements and society, especially in high risk areas and among poor communities. IPCC defines vulnerability to climate change as "*the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change, including climate variability and extremes.*"

Relevant information or indicators needed comprise for example the following:

- People exposed to high risk of natural disasters, by type (e.g. hurricane, flood, etc.) or to the risk of poverty due to climate change;
- Statistics on large infrastructure facilities (ports, airports, bridges, electricity/water supply networks, etc.) at the risk of damage by natural disasters;
- Access to electricity/water supply (as % of population);
- Extreme weather events (number and costs of damage) by type;
- Urbanization statistics and number of large cities with population over a certain threshold (i.e. over 1 million people);
- Human health: climate-related morbidity and mortality, ranging from infectious and chronic diseases to malnutrition and injury;
- Costs and benefits of adaptation[54], per country or region;

[54] OECD had studied the issues in the publication Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instrument: www.oecd.org/env/cc/economicaspectsofadaptationtoclimatechangecostsbenefitsandpolicyinstruments.htm

- Environmental protection expenditure dedicated to climate proofing which aims at incorporating issues of climate change into planning and policies;
- Data for costal zone management;
- Water availability and scarcity statistics, shifts in streams flow, flooding and drought risks;
- Access to water, energy, infrastructure, etc.;
- Regional statistics (gridded, geospatial information);
- Agriculture statistics (gridded information on agricultural holdings, productivity, water use, agricultural input, soil management, land use management, crop diversification, the resilience of crops and livestock.

These data needs are highly specified, and mostly not easily available from existing data sources. Basic statistics would need to be further adjusted to reflect climate change concerns. Adaptation policies require information which is difficult to quantify by precise indicators, such as for example vulnerability and preparedness to withstand adverse climate events. Instead of single indicators, users would need a scoreboard of adaptation indicators.

Information about individual enterprises and persons can be important for emergency response and disaster planning related to climate change. This type of information, however, cannot be sourced from NSOs due to confidentiality constraints. Instead, more generalized information that could be used for analysis and modelling could be provided by NSOs.

3.2 NSO involvement today

NSOs have not played an active role in responding to the data needs of climate change analysis until now. Recently, several initiatives have called for closer involvement of NSOs. For example in 2009, at the global level, the UNSC recognised the role of official statistics in closing the data gaps related to climate change.

As a reaction to the "GDP and beyond" initiative, Eurostat has produced since 2005 a monitoring report of the EU sustainable development strategy which provides statistics related to climate change and energy. The report includes indicators of GHG intensity of energy consumption, projections of GHG emissions, global surface average temperature, gross inland energy consumption by fuel, electricity from renewable sources, share of renewable energy in fuel consumption of transport, combined heat and power generation and implicit tax rate on energy.

Many existing statistics can be important in the future for analysis of climate change impacts. For example data on water availability and use, agricultural production, energy production from renewable sources, forest cover, timber production and health, population growth and migration patterns. As populations in cities continue to grow, the impacts of warmer temperatures can have increased health effects, especially if air quality deteriorates.

NSOs rarely collect data on disasters linked to climate change, but there are a few exceptions, like the Indian statistical office that in collaboration with the National Institute of Disaster Management in India developed a disaster statistics database. NSOs' tasks in providing climate change related statistics thus vary depending on the urgency of climate threats in each country.

The UNECE survey[55] showed that almost 40 per cent of the responding NSOs (18 NSOs) produce some climate change related statistics or indicators. The survey was structured according to the state and impact indicators of climate change, defined by EEA. According to the results, NSOs most often produce statistics on *Water quantity, river floods and droughts* (ten countries) and *Agriculture and forestry* (nine countries). *Atmosphere and climate; terrestrial ecosystems and biodiversity;* and *human health* is covered by NSOs in seven countries, *Freshwater quality and*

[55] The UNECE survey report: www.unece.org/stats/climate.html

biodiversity in six, *Marine biodiversity and ecosystems* in five countries; *Economic impacts* in three countries, and *Cryosphere* only in two countries. No NSO reported producing statistics under the subject of *Soil*.

Table 1: Climate change related indicators produced by NSOs according to the UNECE survey.

TYPE OF CLIMATE CHANGE INDICATORS	NUMBER OF NSOs	INDICATORS PRODUCED BY NSOs
Water quantity, river floods and droughts	10	Indicators on wastewater treatment, water yield, water levels, water allocation, water outflow, water use, water discharge, river floods and drought.
Agriculture and forestry	9	Indicators on crop yields, irrigated area, forest area, area under organic farming, distribution of pests and weeds.
Terrestrial ecosystems and biodiversity	7	Indicators on the extent of natural reserves, diversity of species, leaf and bloom dates, plant hardiness zones, length of growing season, bird wintering ranges, the impact of human settlements, etc.
Atmosphere and climate	7	Average monthly temperatures, precipitation, ozone concentration, number of successive dry days and cyclone intensity.
Human health	7	Indicators on mortality by types of diseases in areas of forest pests and fires compared to overall diseases and mortality; as well as mortality due to heat waves. (In addition, several NSOs mention producing mortality statistics, but not in connection to climate change.)
Freshwater quality and biodiversity	6	Indicators on freshwater biodiversity according to water quality of selected rivers, lakes and drinking water, amount of nitrogen, fish observations and number of threatened species.
Marine biodiversity and ecosystems	4	Indicators describing sea levels, fish stocks, sea surface temperature, ocean heat content and acidity.
Economic impacts	3	Transport statistics, waste statistics, use of cleaner fuels and indicators for the EU monitoring mechanism for GHG emissions
Cryosphere	2	Measurements of snow, ice and glaciers, arctic sea ice, snow cover, snowpack, lake ice.
Soil	0	No indicators mentioned as being produced by NSOs.

The below case study highlights the amount of driving force and response indicators that could be produced based on existing statistics.

Case study: Climate change indicators for Nordic countries using existing statistical data.

CLIMATE CHANGE INDICATORS FOR NORDIC COUNTRIES BASED ON EXISTING DATA

Already in 1999, a cooperation group of the energy and environmental sectors in the Nordic countries prepared an inventory of potential climate change indicators using existing data. Their

report[56] also analysed the results of the selected indicators for the Nordic countries. The below table presents their summary table of climate change indicators. It lists a number of relevant statistics for driving force and response indicators that are mainly available from national statistical systems. The response indicators are in fact mitigation indicators. At the time, the report did not yet consider monitoring of adaptive capacities and vulnerabilities. After 1999, environmental statistics have improved notably and a new inventory would probably result in a longer list of available statistical data.

<table>
<tr><th>Driving force indicators</th><th>Pressure indicators</th><th>State indicators</th><th>Response indicators</th></tr>
<tr><td>Climate and natural conditions: land use, annual forest growth</td><td rowspan="2">Actual emissions: Emission of all GHG (Index (GWP), per capita), of carbon dioxide (Total, per source), of methane per source, of nitrous oxide per source and of other GHG</td><td>Global temperature</td><td>Goals and agreements: GHG emissions compared to requirements of Kyoto Protocol</td></tr>
<tr><td>Population: size, density, development and share of population in major cities</td><td>Atmospheric concentration of carbon dioxide</td><td rowspan="4">Response indicators for CO_2: Environmental taxes and prices of selected fuels (Gasoline prices and taxes, Indices of energy prices (industry/households), Taxes on electricity), Prices on public transport, Energy production from new renewable energy sources, Non-fossil energy use, Energy efficiency and intensity (Energy efficiency in power plants, Industrial energy use per unit production, Industry oil consumption per unit production, Residential energy intensity), Transport (Specific gasoline consumption, passenger cars, number of electric cars), Measures to increase forest growth</td></tr>
<tr><td>Natural resources: Reserves of non-renewable energy sources, renewable energy sources, annual production capacity for hydropower</td><td>Adjusted emissions: Energy consumption adjusted for temperature variations, Emissions of CO_2 equivalents per unit GDP</td><td>Atmospheric concentration of other GHG (Methane, CFC-11 etc)</td></tr>
<tr><td>Transport, roads and infra: Road lengths, Road transport of goods, Domestic passenger transport by air, Personal journeys by mode of transport, Transport of oil and gas by pipelines, by tankers</td><td>Sinks of CO_2: Forest sinks</td><td>Radiative forcing</td></tr>
<tr><td>Economic conditions and production: GDP per capita, expenditures (housing and heating, transport), Consumer price index: total, housing and heating, and transport, Private consumption, Examples of "industry profiles", Value added per unit emission, Industrial structure and exports of goods</td><td></td><td>Other state indicators</td></tr>
<tr><td>Housing and building structure: Part of population in big blocks of flats, District heating of total residential heating, Energy sources for heating by types of buildings, Residential area</td><td></td><td></td><td>Response indicators for CH_4: Taxes on waste deposition, Collection of methane from landfills, Methane from animals</td></tr>
</table>

[56] Inventory of Climate Change Indicators for the Nordic Countries: www.ssb.no/a/histtat/doc/doc_199916.pdf

Energy production and trade: Primary and secondary energy production, Electricity production, Trade with energy, Net imports of electricity			**Response indicators for N_20**: Agriculture (output per unit fertiliser applied), Industry
Production, use and trade of wood products: Production of wood products, Annual removal of forests, Use of fuelwood, Foreign trade			**Response indicators for other GHG**
Energy use: End use of energy (index, commodities, consumer groups, per capita)			
Other driving force indicators: Use of nitrogen fertilisers, Number of domestic animals, Deposition of waste			

In the UNECE survey, some NSOs described their current priorities for the development of climate change related statistics as follows:

- **Drivers**: Energy use by sector and energy consumption; Air emissions and industrial processes;
- **Impacts**: Impact of climate change on human health; Economic impacts of climate change;
- **Mitigation**: Mitigation expenditures; Green renewable energy; Transfers and taxes;
- **Adaptation**: Perceptions of climate change; Adaptation expenditures.

Some NSOs reported about **plans to define a set of climate change indicators**, and to identify the needed data from the statistical system. Some do not have any plans, because they need further consultations within the country with the different institutions involved in the work; or because they are awaiting an international framework for climate change related indicators to be defined.

Some NSOs reported that they **publish climate change indicators even those that are produced by other agencies.** They may publish these data in an annual statistical yearbooks; brief news releases or in their databases. However, most often these indicators are published in thematic publications dealing with sustainable development or environment.

A conclusion from the survey is that at the moment the experience of NSOs in climate change related statistics is at very different levels. It seems that the NSOs have started to collect data and study the phenomena on their own, without the possibility to use common guidelines or exchange of experience. As a consequence, there are various sets of indicators produced with a lack of standardization of definitions and methodologies. These are often developed for the monitoring of national climate change adaptation strategies that a number of countries have developed, in Europe for example Finland, France, Germany, the Netherlands, the United Kingdom, Spain and others.

NSOs could consider providing general statistics and indicators that may be relevant to climate change. An example is the set of indicators based on existing statistics provided by the World Bank (see the case study below). The set includes for example an indicator of the share of urban population that the analysts can link with climate change themselves.

Case study: The World Bank climate change and development indicators using existing statistical data.

WORLD BANK CLIMATE CHANGE AND DEVELOPMENT INDICATORS

The World Bank uses over 40 indicators to create country profiles in support of addressing climate change and development issues. These indicators are mainly brought together by international organizations from existing national statistics.

As stated on the World Bank's website, "Climate change is expected to hit developing countries the hardest. Its effects—higher temperatures, changes in precipitation patterns, rising sea levels, and more frequent weather-related disasters—pose risks for agriculture, food, and water supplies. At stake are recent gains in the fight against poverty, hunger and disease, and the lives and livelihoods of billions of people in developing countries. Addressing climate change requires unprecedented global cooperation across borders. The World Bank Group is helping support developing countries and contributing to a global solution, while tailoring the approach to the differing needs of developing country partners. Data here cover climate systems, exposure to climate impacts, resilience, greenhouse gas emissions, and energy use. Other indicators relevant to climate change are found under other data pages, particularly Environment, Agriculture & Rural Development, Energy & Mining, Health, Infrastructure, Poverty, and Urban Development. "[57]

NSOs are currently implementing the System of Environmental Economic Accounting (SEEA) which has proven its potential and added value in many areas of environmental-economic analysis. A stepwise approach towards developing integrated environmental economic accounts linked to climate change would be beneficial.

3.3 Data gaps and challenges of climate change related statistics

The lack of possibilities to **link official statistical data** to climate observations is a major gap that should be addressed by NSOs. Adding the geographic location and improving data access would notably improve the usefulness of economic, social and environmental data for climate analysis.

Easy linkage would allow analysing for example the impacts of climate change on human settlements, housing, health and mortality. A link with population data would help shed light to pressures imposed to climate by changing population dynamics, migration, urbanization, transport and consumption patterns. Link to tourism statistics would enable monitoring of possible changes in tourist flows due to climate events, and to assess the related losses and gains. Employment data could be useful in documenting possible shifts towards greener jobs, and income statistics linked with climate data would enable the analysis of climate change driven effects on households' economic welfare or even poverty.

Economic statistics linked with climate change would help assess resource efficiency and carbon intensity of industries, as well as the contribution of different industries to GHG emissions. The link would also help analyse the vulnerability of industries to climate change, as well as changes in the conditions for farming and forestry. A link to price statistics is important for monitoring the effectiveness of mitigation and adaptation measures, e.g. through prices of oil, energy and food. Data on science, technology and innovation are particularly useful as tools to assess the effectiveness of international goals regarding technology transfer and development of green technologies.

Linking environmental statistics with climate information is of high relevance when studying climate change. These data, however, are often collected by different agencies, do not follow **harmonised methodologies**, are **not easy to find** and may not be accessible from a single entry point. NSOs cannot respond to all of these data needs, but making data more easily available and developing

[57] The World Bank climate change and development indicators: data.worldbank.org/topic/climate-change

new types of services for example a search engine type of access to statistical microdata could be considered.

Some of the scientific climate data are **difficult to use and understand**. Lack of clarity can lead to data misuse or misinterpretation. Further, climate issues need to be **monitored continuously**, whereas the research projects are often a one-off undertaking. Climate policies would require data to be measured at regular intervals over longer time-periods. Official statistics have a comparative advantage of providing time series on a continuous basis.

The EU Sponsorship Group on Measuring Progress, Well-being and Sustainable Development[58] identified also some data gaps and priorities in relation to climate change:

- Indicators derived on the basis of air emission accounts (emissions);
- Environmentally-extended supply-use and input-output tables on a regular basis to develop carbon footprint indicators (drivers);
- Indicators relevant to climate change mitigation and adaptation.

The emerging data needs, mentioned in the expert meeting, organized by the Task Force in November 2012, included data on **household energy consumption**; **financial aid** related to climate change targeted at developing countries; **data on resilience, vulnerabilities and estimates of population at risk**. Furthermore, some indicators that include causality assumptions, such as mortality due to heat waves were mentioned as a gap.

The national communications on GHG inventories to the UNFCCC include information on the observed and expected impacts of climate change, ways to assess the vulnerability, and possible adaptation measures, strategies and options. Therefore, the Task Force analysed the *In-depth Reviews of National Communications* that highlight several substantive data gaps. The availability of data varies a great deal across countries, and therefore, the following list is for ideas only:

- **Drivers** and factors influencing emissions at different sectors;
- **Impacts** of climate change on key sectors (e.g. tourism);
- **Mitigation:** Cost and effect of policies and measures across sectors (PAMs); Financial resources for mitigation; Technology transfer;
- **Adaptation:** Measures taken; Minimization of adverse impacts of climate change; Vulnerability assessment (e.g. of the health sector and biodiversity); Financial resources for adaptation, investment etc;.

The UNEP list of environmental data gaps underlines the severe data gaps related to climate change (see the case study below). Most of the issues listed as environmental data gaps would also be relevant for data gaps in climate change study.

Case study: Environmental data gaps identified by the United Nations Environmental Programme (UNEP)

UNEP'S LIST OF ENVIRONMENTAL DATA GAPS

UNEP provided the below data gaps for the November 2012 expert meeting:

1) Renewable energy
2) Water quality, quantity and (ground-)water resources
3) Waste (solid & wastewater, disposal and treatment/management)
4) Land degradation
5) Oceans and polar regions (reference data, pollution/health)
6) Ecosystems base data (wetlands etc.)
7) Population density (times series, urban/rural split)
8) Governance (policies, conventions & access to information)
9) Air emissions, urban air quality and health impacts

[58] Final report of the Sponsorship Group on Measuring Progress, Well-being and Sustainable Development: unstats.un.org/unsd/broaderprogress/pdf/Measuring%20Progress,%20Well-being%20and%20Sustainable%20Development.pdf

10) Exotic/invasive species
11) Poverty & prosperity
12) Chemicals exposure & health
13) Glacier & ice, permafrost
14) Technology use
15) Environment, peace and security
16) Goals, targets and reference values
17) Gender and environment (disparities)

Most of the above data gaps also link to lack of relevant data on climate change. A UNEP *Environmental Observing and Assessment Strategy*[59] mentions e.g. the following data gaps:

- "Information about **human activities that affect the environment** is generally more abundant than information about the status or health of the environment itself."

- "The global environmental **conventions** -- climate, biodiversity, desertification -- imply the **need for far more detailed information** on energy use patterns and greenhouse gas emissions, on the health and functioning of ecosystems, and on the pattern of human activities that contributes to land degradation."

- "There was a strong finding that all of **these important data be geo-referenced** so that spatial analysis could be performed."

- There has been "a major emphasis on data collection for research purposes, and **too little emphasis on data collection and analysis to meet current managerial and policy needs**."

- "The majority of present global data sets suffer from the following limitations: consistently small scale and **coarse spatial resolution**; data derived from numerous **source materials that vary in quality and time**; based on **variety of analysis methods**; and frequently **out-of-date**."

Further to the substantive data gaps, several methodological and quality challenges also emerge from the analysis of user needs. Improvements would be needed in the following areas:

- Timeliness of data;
- Availability of long time series (e.g. extending back to 1990 to match the time series from the emission inventories which are also linked to international targets);
- Access to sufficiently disaggregated data, higher level of detail both with regard to economic sectors and geographic breakdown;
- Lack of coherence among data sets and the subsequent inability to match data from different statistical domains for integrated analysis. This issue is partially alleviated with the development of environmental accounts that allow for emission source sectors to be directly matched to economic activities;
- The relevant statistics are scattered across different organisations and are not easy to find.

In summary, climate analysis would require better data on:

- **Drivers:** Economic information connected to climate policies and measures;
- **Impacts:** Socio-economic data linked to climate change, or with a possibility of linkage, should be provided on a regular and systematic manner; Small scale regions, in particular for analysis of the impacts of extreme events;
- **Mitigation:** The use of economic instruments as part of government finance statistics and national accounts, and data on carbon taxes, tradable emissions permits, and other financing mechanisms;
- **Adaptation:** Measures taken to prepare against or adapt to changes to the natural system, including socio-economic parameters; Statistics on vulnerability and exposure to climate extremes.

[59] A UNEP *Environmental Observing and Assessment Strategy:* www.un.org/earthwatch/about/docs/unepstrx.htm

There is also a gap in the capacity needed for the compilation of climate change related statistics in countries, and this challenges data availability. IPCC notes that there is a notable lack of geographical balance in the data on observed changes as a consequence of climate change, with marked scarcity of data in developing countries.[60]

3.4 Challenges with statistical infrastructure

NSOs cannot immediately fill all data gaps concerning climate change related statistics. Their response should be done in steps, and it will challenge the statistical infrastructure of NSOs.

As mentioned in Section 2.4, there is no common definition of statistical infrastructure. The Australian Bureau of Statistics (ABS) defines statistical infrastructure as tools that support the operation of a statistical system. These tools can help to organize the statistical system, improve efficiency, add value, create new outputs or simply perform tasks within the system. Examples of statistical infrastructure include computer systems, metadata repositories, legislation, standards and classifications, frameworks and information development plans. Not all of these issues have specific relevance for climate change related statistics. Therefore, the chapter focuses on the readiness of statistical systems in the following issues: legislation, standards and classifications, frameworks and integration, statistical methods and computer systems, organizational structures and production resources, quality assurance and guidelines, knowledge and cooperation networks.

Climate change related statistics are a new area for most statistical offices although relevant data may be available in the statistical system. This section analyses the parts of the infrastructure that are weakest or missing with regard to compiling or providing climate change related statistics, and highlights some of the important strengths. The section provides ideas for NSOs so that they can analyse their readiness for providing climate change related statistics.

LEGISLATION

There are two main legislative issues in connection with climate change related statistics and statistical offices: confidentiality and linking data from different sources.

Climate research requires sometimes access to microdata and also **detailed geo-referenced statistical data**. Statistical offices have an obligation to ensure confidentiality of the released data. That means, identifiable information about individuals, households and businesses is not released and cannot be derived from the released data. Statistical systems have a legal basis and good practices in place for protecting confidentiality. The growing availability of microdata from official statistics can increase the risk of disclosure and puts more pressure to developing new safe methods to access the needed data. Climate research is **particularly challenging for data confidentiality** due to the need to link data across several datasets and statistical topics, which may result in higher risks of disclosure.

Analysis of climate change related issues requires linking data from different sources, including registers, administrative sources, research data, etc. The ability of statistical offices to get access to these data often requires legal basis and agreement between institutions that are responsible for keeping the data.

STANDARDS AND CLASSIFICATIONS

Standards refer to a comprehensive set of statistical and methodological concepts and definitions used to achieve uniform treatment of statistical issues across time and space. The statistical system has the responsibility for definitions, classifications, nomenclatures, methodologies, certified measurements, accounting standards and data quality of official statistics. These tools assist in maximising the effectiveness of statistical outputs and the efficiency of the production process in

[60] www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf

terms of comparability (over time, space, industry, etc.) and coherence (i.e. the capacity for integration) of the statistics.

While comparability and coherence are important for any dataset, they are particularly important for climate change related statistics. The **ability to combine multiple data sources** is a precondition for compiling these statistics. For many indicators, samples should be geographically representative which could be difficult to achieve without combining the data with administrative registers or observation data sets that provide more detail.

The use of standard classifications helps in the production of consistent and comparable statistics over time, regions and across different collections. The current **statistical classifications do not fully incorporate the requirements** of producing climate change related statistics.

The statistical **classifications, definitions and quality criteria need to be adapted** regularly to include new aspects. The statistical system has a structure for periodic reviews of its various sub-systems, which can be used to examine this new user need. For example, the classification for different industries, known as the International Standard Industrial Classification of All Economic Activities (ISIC), was revised recently to include more detail in the services sector due to the increasing importance of service activities. The same type of review could be undertaken for this and other classification systems with respect to aspects related to climate change.

Statistical offices approach new phenomena to be measured by first ensuring that **common definitions can be agreed upon** and then designing **methodological guidelines** for data collection and compilation.

FRAMEWORKS AND INTEGRATION

Statistical frameworks help to align the information needs of users, including specific statistics and indicators, with the data sources, classifications, methods and results. Statistical frameworks also consider links between different subject areas and may incorporate data requirements from several fields. As an example, statistical business registers could be useful for producing climate change related statistics if they included a geo-reference for all relevant data. Similar benefits could be identified while **reviewing connections of existing statistical frameworks with climate change**.

A framework is a set of assumptions, concepts, principles values and practices that underpin statistical production. It provides a context and guidance especially in the planning phase of new or developed statistics. Frameworks can be simple, developed for a narrow subject of interest or can be highly complex and encompass entire subject matter area. They also help to integrate and present data in a meaningful way. Such a framework should be developed for climate change related statistics in the longer term.

Examples of statistical frameworks that are linked to climate change related statistics include *the SEEA* [61] and *the UN Framework for the development of environment statistics (FDES)* [62]. SEEA contains the internationally agreed standards for producing environment accounts and linking them with economic statistics, and FDES provides an organizing structure to guide the production of environment statistics bringing together data from various subject areas and sources. The new version of FDES now considers the links between data needed for monitoring climate change and existing environmental statistics.

Similar developments would be needed for improving the linkage of climate change information with social and economic data, such as with the **System of National Accounts** (SNA). Air emissions accounts are an example of the usefulness of linking national accounts data with climate change

[61] The System of Environmental-Economic Accounting (SEEA): unstats.un.org/unsd/envaccounting/seea.asp

[62] Framework for the Development of Environment Statistics (FDES) 2013: unstats.un.org/unsd/statcom/doc13/BG-FDES-Environment.pdf

related data. These accounts produced by all NSOs in the EU and in many other countries, and they present annual data on GHG emissions and other air pollutants in a compatible way with national accounts and assign emissions to the inducing industries according to the International Standard Industrial Classification (ISIC/NACE). Examining emissions with economic data helps identify sources of emissions, analyse the environmental pressure caused by economic activities, and assess the emission intensiveness of economic activities. The Inter-Secretariat Working Group on National Accounts (ISWGNA) drafted additional instructions for recording tradable emission permits in national accounts in 2011, but noted that the issue needs to be reviewed again in the future[63]. Ways to strengthen the links between national accounts and climate data, such as emission trading data (the carbon market) should be considered.

Synergies may be found with other statistical frameworks as well. For instance, the possible **links of energy statistics to climate change related data should be reviewed**.

STATISTICAL METHODS AND COMPUTER SYSTEMS

Spatial statistics often require highly complicated and sophisticated methods, for instance spatial interpolation. Therefore, climate change related statistics might require **development of new statistical methods** not used in the national statistical system otherwise. On the other hand, many consider that any modelling approaches, based on hypothetical assumptions, should be left outside official statistics.

To measure the impacts and vulnerability to climate change, different types of data from very different sources need to be brought together. This places **major requirements for the capacity and inter-functionality of IT systems** and requires **wide access to different data sets** thus underlying the importance of statistical systems to be involved. The **data linkage techniques** and methods of **data reconciliation** require improvements. Furthermore, ways for facilitating research and statistical activities linking relevant data across statistical domains should be sought.

Making use of geographic information systems (GIS) would benefit climate change analysis. Much of climate change related statistics is very closely related to spatial information e.g. meteorological data and population in danger of floods. NSOs would need to develop their capacity in geo-referencing and spatial statistics and find ways to enable research and statistical activities that link climate data with other statistical data sets. The need for geocoding basic data should be reviewed across statistics. One of the challenges is that **sample surveys do not provide detailed enough regional data** for analysis of, for example, the regional economic and social impacts of extreme weather events.

NSOs' **capacity to provide geospatial data** is not yet sufficiently developed to match the detailed data needs of climate change analysis. The Australian Bureau of Statistics (ABS) recently analysed the results of a global consultation on statistical-geospatial frameworks (with 52 replies from countries) at the request of the United Nations Statistical Commission (UNSC). The results show that many NSOs have developed or are working on developing ways to provide statistical information for smaller geographic regions. There is a great potential in the use of geographical information systems (GIS) for spatial analysis of the impacts of and vulnerability to climate change. For example in Mexico and Brazil, geospatial and statistical activities are closely integrated and undertaken by a single organization, the NSO. In addition, for example the NSOs of Canada, Colombia, Netherlands, New Zealand and Singapore have a range of internal geospatial capabilities and a good level of collaboration with their national geospatial community. In Europe, the NSOs provide geospatial data support for the INSPIRE (Infrastructure for Spatial Information in the European Community) programme. As a conclusion of the global consultation, UNSD was asked to establish an expert group

[63] SNA News: The Recording of Emission Permits Issued under Cap and Trade Schemes in the National Accounts, clarification by the Inter-Secretariat Working Group on National Accounts: unstats.un.org/unsd/nationalaccount/sna/nn30-31-en.pdf

composed of representatives of both statistical and geospatial communities to develop a global standard for the integration of statistical and geospatial information.

Currently, **internationally recommended methodology does not exist** for most of climate change related statistics. Statisticians are **experienced in applying adjustments** to make measures comparable over time and adjust them, for example, for seasonal variation. These adjustments that eliminate the effect of some known source of influence, and leave only the changes caused by unknown sources of influence and natural variation, could be useful for measuring climate change related phenomena.

ORGANIZATIONAL STRUCTURES AND PRODUCTION RESOURCES

The developing role of NSOs in climate change related statistics **may call for organizational changes** in statistical offices. Most statistical offices have traditionally been organized according to either 'subject matter' (where economic statistics could be one of the units) or 'function' (where data collection could be one of the units), or a mix of the two. The development of cross-cutting areas, such as climate change, requires an organization that supports collaboration across different structural units and subject areas.

Production **resources for new areas of statistics are naturally relatively small**, for instance in environmental or climate change related statistics. For the moment, NSOs may not even mention measuring climate change related issues as a responsibility of one of the organizational units.

Standardization of production processes could enable some re-allocation of resources to new areas, and improve access to data across organisational units. Partly, however, existing data could be re-sorted to match many of the new data needs with limited additional costs. This requires better awareness of the data needs related to climate change and the data available from other producers of climate information.

QUALITY ASSURANCE AND GUIDELINES

Different quality criteria guide the production of official statistics, scientific research and climate change related information. Nowadays, it is **difficult for the user to assess the quality** of climate information as it comes from various sources.

A challenge sometimes mentioned is that while research provides ad-hoc insights into the causes and impacts of climate change, it usually fails to provide **regularly updated information and time series**. Measuring change in time, on the other hand, is the core competence of statistical offices. A core set of statistics should be defined and be provided regularly for monitoring developments related to climate change.

Climate change is a highly sensitive issue for policy making. Therefore, neutrality of climate change data is very important. Involving NSOs in the compilation could help to prevent political interference to compilation of climate change related information. The **strong professional independence** of NSOs in most countries could help to increase trust in climate change related data and thus support the climate debate.

Opinions have been expressed that climate change related statistics should be **included into the framework of official statistics** so that their quality could be ensured. Some users call for quality stamped climate statistics and better metadata that explains where the data come from, how they have been produced and how they should be interpreted. Some countries have an established label of "official statistics" and a clear process and roles for the organizations that are part of producers of official statistics.

The NSOs normally has the **coordination role of this system of official statistics**. In Mexico, for example, statistics that are of national interest belong to the sphere of official statistics and have to follow certain quality criteria. In the United Kingdom, agencies producing statistics have to apply for

the national statistics badge, which may be granted based on an assessment of quality of production processes, not data quality directly. The production of environmental statistics in various national agencies could also benefit from closer coordination by NSOs.

KNOWLEDGE AND CAPACITY

Given that the statistical system includes economic, social and environmental data, the NSOs have acquired knowledge for measuring varying societal issues. However, climate change involves complex interactions between systems, is multi-disciplinary and anchored largely in the natural sciences. Furthermore, methods for producing spatial statistics may not be so familiar to all NSOs. Measuring climate change **requires specific knowledge**, and many NSOs currently lack the qualifications necessary to do good work in this area.

The substantive knowledge in climate issues is now spread around many rather specialized agencies, ministries and research institutes that produce and use climate change related data. Climate observations are collected usually outside the statistical system by meteorological and atmospheric monitoring networks. Scientific research has a predominant role in providing climate information. At the moment, **most statistical offices do not mention climate change as one of the statistical topics they work with**.

Statisticians would need **training** to start measuring climate change related issues. The knowledge gaps should also be taken into account so as to **recruit staff with the appropriate professional training and experience.** Most potential employees, however, might not have the combination of statistical work experience and the required substance knowledge. Therefore, also training on the job is needed.

The low and middle income countries are often most severely struck by climate change. At the same time, their **capacity to produce the relevant climate change related information** is often low. Exchange of current practices and mutual support among countries would be helpful.

Building credibility as a player in the field of science-based climate analysis is a challenge, because statistical offices are relative newcomers to climate issues and do not have large teams of professionals dedicated to this area of work.

COOPERATION NETWORKS

Various types of information are needed for analysing the causes and impacts of climate change. One agency cannot produce all the required information. No statistical agency can function effectively without systematic cooperation with outside contacts[64]. Thus, **good cooperation is essential** to finding ways to better respond to the growing information needs.

Many of the current challenges countries face in developing climate change related statistics are linked to an underdeveloped institutional setting **or unclear division of work between organizations**. This is the case both nationally, and to some extent also internationally.

With regard to cross-sectional data, such as climate change related statistics, close cooperation and networking with other organizations are a necessity. Coordination of joint work of different organizations is also important for ensuring efficient use of resources and division of work.

In the UNECE survey, NSOs underlined the **need to improve international comparability** of climate change related statistics in close cooperation **and to enhance statistical capacities** to produce these statistics. They also mentioned the necessity to **enhance collaboration** with the research community and between institutions involved in producing these statistics, better cooperation and coordination as a tool towards more efficient and consistent data collection, compilation and dissemination.

[64] See Handbook of Statistical Organization. p. 175-176: paris21.org/sites/default/files/1153.pdf

Case study: Capacity gaps identified in the UNEP Environmental Observing and Assessment Strategy

UNEP ENVIRONMENTAL OBSERVING AND ASSESSMENT STRATEGY

The UNEP *Environmental Observing and Assessment Strategy*[65] highlights several critical gaps that relate to statistical capacity and infrastructure:

- "The most serious problem in many developing countries is not the lack of information, but the failure to **share existing information among agencies**."

- "At a more strategic level, these gaps relate to: **lack of guidance and coordination** of environmentally related observing (fragmented, incomplete and overlapping); too **little emphasis on observing of causes and impacts**; and too **little attention to problem solving**, i.e. existing and alternative policies and actions."

- "Recent experience by UNEP, but also by many other organizations involved in regional or global data collection, particularly Eurostat, UNECE, EEA and OECD, shows that the problem of critical data gaps **will not be solved for a long time to come with the current approach to data collection**. The complexity and rapid evolution of environmental problems and knowledge mean that new data sets are required constantly."

3.5 Conclusions on climate change related statistics

1. Climate change and its impact on society and environment touches upon almost every aspect of environmental data collection. Climate relevant statistics comprise a very broad range of datasets that stretch across the entire statistical framework, beyond the spheres of climate science and research. Most of the data are not collected specifically for climate analysis, and this creates **problems of linking** the data that would be needed for integrated analyses.

2. NSSs already produce a considerable quantity of data relevant for climate change. NSOs are well positioned to collect, harmonize and disseminate climate change related statistics. A step by step approach should be adopted in facing this challenge, (1) facilitating access to the existing statistics, (2) improving the usefulness of existing data from different domains and (3) developing new statistics to fill priority data gaps.

3. First, facilitating access to existing statistics means bringing together and disseminating existing data that are relevant for climate change analysis. NSOs could have a central role in **ensuring access** to climate change related statistics, even when the data are not a part of official statistics. NSOs could contribute by making data more easily available and for example by developing new types of services for example a search engine type of access to statistical microdata.

4. Second, improving the usefulness of existing data for climate change analysis requires reviewing data collections and improving data linking across different statistics and producers' datasets. It entails **a review of existing statistics and data collection systems** to see if they can be used to identify climate change related issues, such as relevant information on renewable energy sources, "green" jobs, new or recurrent diseases linked to climate change etc. This would necessitate strengthening the capacity of NSOs in linking datasets produced by various organizations. Data matching requires not only better technical capacity, but sufficient legislative environment for closer cooperation with other data producers and gradually a higher degree of data harmonization.

5. Third, NSOs should determine **what additional statistics might be needed** in the longer term for climate change analysis. Data needs were discussed in Section **Error! Reference source not found.**. For example, to support analysis of drivers of climate change, NSOs should continue

[65] A UNEP *Environmental Observing and Assessment Strategy:* www.un.org/earthwatch/about/docs/unepstrx.htm

efforts to connect economic information to climate change related issues. NSOs should consider how to contribute to monitoring the impact of climate change on biodiversity and ecosystems. Reliable data on the use of economic instruments in mitigation efforts will be needed. Regular statistics should also be developed to monitor adaptation, including resilience, risks and vulnerability of population groups and the preparedness to withstand the adverse impacts of climate change.

6. The changes require **improvements in the current infrastructure of NSOs**, such as balancing between detailed data needs and confidentiality; reviewing different statistical frameworks and standards; and in the longer term adjusting organizational structures to support production of cross-sectional statistics.

7. According to the vision of the High-level Group on the modernization of statistical processes and services (HLG), "**the challenge for statistical organizations is to be sufficiently flexible** and agile to provide statistics according to user needs, at an acceptable cost." They state that "in some specific statistical domains, only cross border data make sense, for example globalization, enterprise groups and climate change." Cross-sectional statistics, such as climate change related statistics, may pose challenges to the structure and functioning of statistical organizations. Thus, producing climate change related statistics may be easier to undertake in an organization focused on serving the needs of different user categories and producing outputs by re-sorting and combining the collected data to match the user needs.

8. Statisticians will need to build **new kinds of expertise** for producing climate change related statistics. This includes building capacity to produce geo-referenced data; learning new methods of spatial statistics; improving the ability to match data from multiple sources; and building substantive knowledge in climate issues. Closer networking with organizations involved in climate issues would be helpful.

9. The production of climate change related data **lacks coordination**. The users of climate data would benefit from better harmonization of concepts, classifications, methods and quality standards. NSOs role is to lead the way in the harmonization and standardization of statistical production and to ensure high–quality information produced, following common guidelines. Currently, such guidelines do not exist for most climate change related statistics other than GHG inventories. In some areas, the existing practices need to be promoted among the involved agencies.

10. NSOs will need **further guidelines** on how to take into account the needs of climate change analysis in official statistics. For this, the links of the existing statistical frameworks to climate issues should be explored further. In the longer run, methodological guidelines for data collection and compilation on climate change related statistics should be developed.

11. A number of countries have developed national climate change adaptation strategies, based on various indicators sets to inform public environmental policies. **Development of indicator sets should be internationally coordinated** to achieve comparability across countries. In the longer term, high relevance areas for climate change related issues should be defined and provided as official statistics regularly.

4 RECOMMENDATIONS

This chapter introduces the Task Force's recommendations to national statistical offices (NSOs) for improving climate change related statistics, and enhancing their support to greenhouse gas inventories. The recommendations are grouped as follows: (1) recommendations on the data needed for greenhouse gas (GHG) inventories; (2) recommendations on climate change related statistics and (3) recommendations on statistical infrastructure required for this work. In the end of the chapter, the Task Force suggests an agenda for further work at international level.

These recommendations are based on the analysis by the Task Force and the following sources:

- A UNECE survey of national statistical offices (48 countries replied) on their involvement in climate change related statistics and greenhouse gas inventories;
- Stakeholder interviews with users of official statistics in matters related to climate change;
- Discussion of the interim recommendations by the Bureau of the Conference of European Statisticians (CES) in February 2013 and the CES plenary session in June 2013, and a written consultation of the interim recommendations in June-July 2013 among CES members;
- Feedback from two expert meetings: on 19-20 November 2012 to discuss the initial findings and to identify directions for future; and on 8-9 October 2013 to review the draft report.

4.1 Recommendations on greenhouse gas inventories

1. NSOs must **improve data and statistics required for greenhouse gas inventories**; including, energy, industry, transport, agriculture, waste, forestry and land-use statistics. To harmonize and streamline their work on GHG inventories, the NSOs should consider the following issues and actions:

   - Currently, existing NSOs' statistics are not used to their full potential for emission inventories and some duplication of data collection exists. NSOs should <u>be more aware of how their data are or could be used in the inventories</u> to be able to take into account the related data needs. Annual *Inventory Review Reports* would be an important source of information for NSOs to identify national data improvement needs;

   - NSOs should take the initiative in <u>improving coherence of emission inventories and official statistics</u> where possible. NSOs, together with other involved agencies, should consider the possibilities for simplifying the calculation process to use existing data as much as possible. This in turn could improve the quality of GHG estimates and consistency with other statistics. Communicating data on emissions should be improved by clarifying the contents of emission classes in the Common Reporting Format (CRF) and providing information of GHG gases according to the International Standard Industrial Classification (ISIC/NACE). Adjustments are being done to the CRF-classification[66] that may be a step towards the right direction;

   - In particular, emphasis should be put on <u>improving the quality of energy statistics</u> where NSOs are an important data provider. Given the importance of good quality energy balances, energy balance compilers (whether NSOs or other bodies) should aim to improve the quality of the energy statistics and energy balances reported internationally whilst helping to ensure the consistency of activity data reported in GHG inventories with the energy balances reported to international organizations (e.g. to Eurostat and International Energy Agency (IEA));

[66] The draft new CRF-tables are at: unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/7691.php

- Several countries need to improve data on waste, land use, the production of heat and electricity for own use and on renewable energy sources. Policy interest exists for data on ”off-shored” emissions and GHG emissions linked to economic sectors;
- Users request timelier emission estimates, and GHG inventories would benefit from improved timeliness of activity data. More timely provision of finalized energy balances to GHG inventory compilers would also be useful. In some cases, the length of time series is not sufficient for analysing the inventories, such as the drivers of emissions. The inventories require the use of detailed data. Thus access to sufficiently disaggregated source data continues to be an issue. Data confidentiality often prevents inventory compilers from full access to the needed data.

2. NSOs should **be considered as official institutions in the national greenhouse gas inventory systems** in all countries, and they should **be proactive in reaching out to national GHG inventory compilers**. NSOs should develop their role and involvement in GHG inventory compilation along the following lines:

   - Considering that NSOs provide a considerable portion of the statistics required for GHG inventories, NSOs should be given a clear role in providing statistics, assisting in calculations as needed and assisting with quality assurance. This should be established gradually through official agreements, for example by including NSOs in the national systems responsible for GHG inventories. This could be done simply by explicitly noting the role of the NSO in the inventory documentation submitted to the UNFCCC or more formally via a Memorandum of Understanding between the NSO and the national entity responsible for the inventory. This would provide certainty about the roles and responsibilities of each institution, and closer co-operation would help improve the quality of GHG inventories;
   - National legislation should be reviewed to ensure that it facilitates effective cooperation between agencies belonging to the national emission inventory system and provide a legal basis for clear division of work and exchange of data as required for the inventories. The legislation should be in accordance with the national statistical law;
   - NSOs need to work with the inventory compilers to identify and evaluate NSOs statistics needed for emission inventories to see if they are fit-for-purpose. Changes to NSO data availability or collections systems should be considered first where effective changes can be made. To this end, NSOs and inventory compilers should review the existing reporting systems for emission inventories to identify overlaps and areas for synergies, and to make use of the data available from the statistical system. The aim would be to reduce costs, avoid duplicate data reporting and move towards multipurpose data systems serving various user needs;
   - The experience of NSOs in quality assurance would be useful in supporting the efforts at strengthening the quality of GHG inventory data. In particular, NSOs could be more involved in applying the “measureable, reportable and verifiable” approach to review the quality of data underpinning the inventories. NSOs should strengthen the quality assurance and quality control of activity data across all of the sectors reported in GHG inventories.

3. **The international statistical community should take an active role** in contributing to the global GHG inventory system.

   - Existing NSOs statistics might be made more useful for emission inventories if the statistical community were consulted by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) when drafting data requirements. NSOs should, therefore be included in, or at least consulted on, emission inventory methodology development. This in turn would help reduce the costs of the global system and improve the quality of inventories;

- Closer involvement of the statistical community in the processes linked to international climate accords would help countries fulfil the related data requirements. The statistical community should, therefore, actively follow up on the outcomes of the UNFCCC Conferences of the Parties, in particular those related to the Measurement, Reporting and Verification (MRV) system The statistical community can add value by assessing data availability and feasibility of requirements related to the Kyoto protocol, and by preparing themselves for new data requirements, for example regarding the flexibility mechanisms[67];
- The 17th UNFCCC Conference of the Parties in Durban agreed to put in place by 2015 a global "protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties" to be implemented from 2020[68], essentially moving away from the current divide between industrialized and developing countries in future accords. This means that all countries may be required to submit annual inventories. Countries that are just building up the inventory system should involve the NSO from the beginning to avoid creating burdensome and overlapping data reporting systems. There is, therefore, an important opportunity in the next few years to involve NSOs to provide a solid foundation for emission inventories in countries that will be obliged to compile them;
- The international statistical community and many NSOs can be important partners in building capacity and knowledge required for greenhouse gas inventories, quality assurance and sound statistical methodology. Many NSOs have extensive experience in statistical capacity building and improving availability of evidence based information for monitoring development towards international development goals;
- There is scope for more sharing of good practice internationally between NSOs and inventory agencies, and there should be greater focus on making this happen at the international level too.

4.2 Recommendations on climate change related statistics (other than source data for greenhouse gas inventories)

4. NSOs must improve the contribution of official statistics to climate change analysis. One of the first steps can be to **facilitate access** to the existing information. To do this, NSOs may consider the following issues and actions:

- NSOs' communication channels would provide an efficient means of bringing together and disseminating climate change related statistics. Communicating statistics is a core business of statistical offices. For the moment, the information needed for understanding the causes and consequences of climate change is scattered across various organizations. Creating portals for climate change related statistics would make them more accessible and easier to use, even when the information is not produced by the NSO;
- Although NSOs do not produce most of the scientific data related to climate change, the possibility of cooperation with scientific organizations (e.g. meteorological services) in the dissemination of their data (e.g. temperature, extreme weather events) should be considered;
- Access to microdata is important for policy makers and scientists working on climate change. New approaches should be considered for dealing with confidentiality issues to ensure a better response to climate data needs.

[67] Flexible mechanisms refer to Emissions Trading, the Clean Development Mechanism and Joint Implementation defined under the Kyoto Protocol and intended to lower the overall costs of achieving its emissions targets.

[68] Decision 1/CP.17.

5. **The usefulness of the existing environmental, social and economic statistics for climate change analysis should be improved**, for example by better structuring the existing information. To do this, NSOs may consider the following issues and actions:

   - NSOs should review their statistical programs and data collections from the view point of the data needs of climate change analysis, for example to see if they can be used for measuring climate change related issues, such as renewable energy sources, "green" jobs, new or recurrent diseases linked to climate change etc;
   - The lack of coherence among data sets and the difficulties in matching data from different statistical domains should be addressed. NSOs should put efforts in improving the possibility to link their socio-economic data sets with climate observations. Consistency of environmental statistics should be improved by means of increased methodological and practical harmonization;
   - Geo-referencing all relevant data to accommodate for better analysis of the spatial dimension of data linked to climate change. This would also improve linkage of existing data with climate observations;
   - To address climate change, statistics are required according to new geographical areas, such as coastal areas or areas prone to flooding or drought. Providing more information related to urban areas will become more important, especially in developing countries;
   - Providing more detailed data related to climate change, such as data on food production, water use, health and diseases, tourism, population and population growth would benefit climate change analysis.

6. NSOs should **review the key data needs of climate policy makers and analysts in their country, and consider development of new statistics**. There is a substantial scope for the NSOs to manage the data necessary for development of international and national climate change policies and monitoring their success. The NSOs need to engage with users to better define the new role of statistical offices and other public bodies so as to better respond to users' needs. When considering the production of new statistics, it is important to recall the key competencies of NSOs and take into consideration their traditional boundaries. For instance, NSOs do not usually compile forecasts or make judgements about cause-effect relationships. Based on the analysis presented in Chapter 3, the key data gaps to consider include among others:

   - To analyse drivers of climate change, NSOs should continue efforts to connect economic information to climate change related issues, for example to develop environmental accounts that allow for emission source sectors to be directly matched to economic activities;
   - NSOs should consider how to contribute to the on-going efforts to monitor biodiversity and ecosystems. Climate change will have significant and long-term impacts on ecosystems and the related goods and services arising from ecosystems. Establishing baseline estimates of ecosystems today will make the assessment of the impacts of climate change more robust;
   - Reliable data on the use of economic instruments in mitigation efforts will be needed as new economic instruments are developed to deal with climate change (e.g. carbon taxes, tradable emissions permits, subsidies). The measurement of the financial flows associated with the use of these instruments and the inclusion of these flows in a clear, consistent and observable fashion in government finance statistics and national accounts needs to be addressed;
   - Reliable and regular statistics and indicators should be developed addressing adaptation and adaptive capacity, including indicators on resilience, risks and vulnerability of population groups and the preparedness to withstand the adverse impacts of climate change. Examples

of relevant indicators include populations at the risk of natural disasters or at the risk of poverty due to changing climate (increased heat/cold, desertification, etc.).

4.3 Recommendations on statistical infrastructure

7. NSOs should **review classification systems, registers, definitions and statistical frameworks to see that the needs related to climate change analysis are appropriately addressed**. In doing so, NSOs may consider the following issues and actions:

   - Consideration should be given to the needs of climate change analysis in different statistical standards and frameworks. At international level, future revisions of standards and frameworks used in official statistics should give consideration to the data needs of climate change analysis. For instance, changes in the System of National Accounts (SNA) might improve the availability of statistics to understand emission trading systems;

   - The obstacles to linking between statistics, and in particular of environmental and energy statistics, both with each other and with the national accounts, should be identified and addressed. Examples include reviewing differences in the concept of 'energy' across statistics, ensuring data consistency across organizational borders and testing the use of supply-use and input-output data for linking industrial production to energy use and air emissions.

8. Statisticians will gradually require **new kinds of expertise and ability to adopt new methodologies** for producing climate change related statistics. To strengthen the knowledge of staff, NSOs may consider the following issues and actions:

   - Traditionally, statisticians have been professional data managers specialized in narrow topics. Climate change related statistics require the understanding of natural science and knowledge that cuts across many areas;

   - Statisticians should also better understand the relevance and use of existing statistical data for climate change impact analysis and policy assessment. NSOs will be required to look beyond traditional disciplines when recruiting staff;

   - Reconciliation of data derived from several sources for climate analysis would necessitate strengthening the capacity of NSOs and skills of staff in linking datasets produced by various organizations. New technical infrastructure and solutions may need to be adopted and used by NSOs to improve data linkage;

   - NSOs' staff should also become familiar with new methodologies. For example, they should understand the GHG inventory methodologies and their development to the necessary extent. The statistical system needs to develop methodologies and tools for producing and using geo-referenced data. NSOs should also seek new methods for dealing with confidentiality issues and microdata access to ensure a better response to climate data needs.

9. In the longer run, **organizational changes may be needed** in NSOs to support the production of climate change related statistics that cut across the statistical system. To do this, NSOs may consider the following issues and actions:

   - As a first step, a person or persons should be assigned the responsibility of climate change related statistics and data for GHG inventories;

   - In the longer term, the organizational structure of NSOs may require modernizing or changing to support production of climate change related statistics that cut across the statistical system. According to the HLG for the modernization of statistical processes and services, "the challenge for statistical organizations is to be sufficiently flexible and agile to

provide statistics according to user needs, at an acceptable cost." They explain that cross border data are necessary, but may pose challenges to the structure and functioning of NSOs;

- In the course of work, sufficient resources should be earmarked for the development of environment statistics and climate change related statistics. Modernizing statistical production may also release resources that could be used to meet new user needs related to climate change.

4.4 Research agenda

These are the first recommendations developed to help NSOs improve climate change related statistics, and enhance their support to greenhouse gas inventories. NSOs will need further guidelines on how to take into account the needs of climate change analysis and GHG inventories in practice.

The longer term goal should be to define a set of regularly produced statistics on climate change that could be developed as part of official statistics. Several countries are currently developing climate change indicator sets for policy purposes. This work should be internationally coordinated to enable availability of comparable statistics across countries.

The Task Force has identified the following issues to be included in the future research agenda of further work at international level:

- Develop structures or frameworks for organizing the different climate change related statistics and their metadata;
- Develop a set of climate change variables or indicators as a core set for regular production as part of official statistics. It is unlikely that a single set of indicators at international level would be universally applicable, but a benchmark set could be defined;
- Create methodological guidelines for the compilation of the core set of climate change related statistics;
- Examine the need to update existing statistical standards or classifications (SNA, SEEA etc.) to better serve climate change data needs. For example, the Classification of Statistical Activities (CSA)[69] includes a breakdown into detailed subject areas for long-established statistical areas as social and economic statistics, but this is not the case with environment which is presented as one category without further hierarchical breakdown. Climate change belongs to this category in the CSA;
- Develop a standard approach for mapping classifications used in GHG inventories with those used in official statistics, for example to link the Standard International Energy Product Classification (SIEC) to the Central Product Classification (CPC) and review further the links of CRF-classification to ISIC/NACE.

An important challenge will be to find the balance between country specific indicator development and setting standards to improve quality and comparability of climate change related statistics across countries. Both will be needed – standard methodologies cannot be fixed without country experience and pioneering work, but standards should be developed before too diversified statistical practices are in place.

The international statistical community should try to establish coordination between UNFCCC, IPCC and the system of official statistics. Where could the connection be made and how? All NSOs cannot be involved in the IPCC methodology development. Instead, some kind of official channel for the international coordination of work with IPCC and UNFCCC is needed.

[69] Classification of Statistical Activities: www1.unece.org/stat/platform/display/DISA

These recommendations should be discussed by NSOs to spread the understanding of the importance of NSO involvement in climate change related statistics. In February 2013, the Bureau of the Conference of European Statisticians stressed the need for urgent action by statistical offices to fill gaps in this domain. This document helps NSOs get started. In the next few years, it would be important to share good practices to accumulate knowledge and experience for further work.

ANNEX I
Terms of reference

ECONOMIC COMMISSION FOR EUROPE

CONFERENCE OF EUROPEAN STATISTICIANS

ECE/CES/BUR/2011/NOV/9 Rev.

13 October 2011

Second Meeting of the 2011/2012 Bureau

Geneva, Switzerland, 2-3 November 2011

Approved

Item 4(c) of the Provisional Agenda

TERMS OF REFERENCE FOR A TASK FORCE ON CLIMATE CHANGE RELATED STATISTICS

Prepared by the UNECE secretariat

I. BACKGROUND

1. In recent years, several initiatives have highlighted the need to develop climate change related statistics for the purpose of climate change mitigation, impact and vulnerability analysis, and adaptation. The Stiglitz-Sen-Fitoussi Commission's report called for a set of well-chosen indicators to describe the environmental aspect of sustainability, including climate change. The need to complement Gross Domestic Product (GDP) with other statistics, e.g. to address climate change, had also been noted by the EU Commission's initiative "GDP and beyond". More recently, an EU sponsorship group on measuring progress, well-being and sustainable development has selected further development of climate change indicators to be among its priorities for future work.

2. The UN Statistical Commission (UNSC) has also supported the work on developing climate change related statistics. Led by the UN Statistics Division in New York, two Conferences on Climate Change and Official Statistics were organized in 2008. Soon thereafter, the Australian Bureau of Statistics prepared a programme review for the UNSC on how official statistics can better contribute to the climate change debate. The programme review recommended developing a framework for climate change related statistics, improving the quality of greenhouse gas (GHG) inventories and advocating the use of official statistics for climate change policies. The UNSC recognised the role of official statistics in closing these data gaps, and emphasised the need for better understanding of the data requirements of stakeholders.

3. Climate change related statistics is a new area for the national statistical offices (NSOs), and therefore, the UNECE considers important that the NSOs define their role among the institutions involved in producing climate change related statistics. During its two latest Commission sessions, the UNECE stressed the need to work towards robust, timely and comparable statistics on climate change in the context of environmental indicators.

4. In view of the latest developments, the Bureau of the Conference of European Statisticians (CES) decided to take stock of the current state of work on climate change related statistics in the NSOs, and asked the UNECE to conduct a survey. The aim of the survey was to find out the extent to which the NSOs are involved in producing climate change related statistics and to identify issues of common concern for further work at international level.

5. The survey was also undertaken at the request of the UN Committee of Experts on Environmental-Economic Accounting, and the UN Statistics Division supported the work. The

questionnaire was consulted with experts from Statistics Norway, Statistics Finland, Eurostat and the European Environment Agency (EEA).

6. The survey covered 69 countries reaching beyond UNECE region, and 47 countries replied. A report on the findings is provided in document ECE/CES/BUR/2011/NOV/9 Add.1. According to the survey, 75 per cent of NSOs that replied participate in producing GHG inventories, whilst almost 40 per cent of them produce climate change indicators. Many countries have concrete plans on how to improve work in this area.

7. The respondents identified the following priorities for international work:

- establishing a framework for climate change indicators;
- defining areas for NSOs to improve the accuracy and quality of GHG inventories;
- harmonising and mapping the GHG and statistical classifications;
- considering the role of NSOs among other agencies dealing with climate change related statistics.

8. The draft Terms of Reference are prepared to address the needs identified by countries in the survey. The draft was consulted with Statistics Finland, Statistics Norway, Eurostat and EEA, and incorporates their comments.

II. MANDATE

9. The work of the Task Force is conducted within the framework of the Conference of European Statisticians (CES) and its Bureau. The Task Force will be created for a period of two years, after which it will submit a final report.

III. OBJECTIVE

10. The main objective of the Task Force is to identify practical steps to support future development of climate change related statistics to meet user needs, and to enhance the role of official statistics in GHG inventories.

11. In pursuing this objective, the Task Force will discuss and collaborate with other bodies involved in international work on climate change related statistics, including the work of the United Nations Framework Convention on Climate Change (UNFCCC), the Intergovernmental Panel on Climate Change (IPCC), Eurostat, EEA and UNSD. Regular progress reports will be submitted for consultation with the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA) established by the UN Statistical Commission.

12. The work will address issues of climate change related statistics, in particular those related to GHG inventories, statistics on the consequences of climate change and measures taken to reduce climate change and its adverse effects.

IV. PLANNED ACTIVITIES AND OUTPUTS

13. The Task Force will undertake the following activities:

(a) Define the scope of work for the Task Force and what is meant by climate change related statistics;

(b) Assess the gap between the user needs and the available climate change related statistics, including international reporting activities;

(c) Explore ways for harmonising the GHG and statistical practices by mapping the classifications and identifying what data NSOs have for GHG inventories;

(d) Identify possibilities to simplify the calculation and improve the quality of GHG data, and consider issues for further revisions;

(e) Review links between climate change related statistics, the System of Environmental-Economic Accounting (SEEA) and the UN Framework for the development of environment statistics (FDES), both currently under revision.

(f) Consider organisational issues and the role of NSOs in climate change related statistics.

14. The output will be a review of the current state of climate change related statistics and possibilities to develop and streamline the work, with a proposal for:

(a) Developing climate change related statistics for evidence-based climate change policies: concrete steps and priorities for further work;

(b) Harmonising and streamlining the work of NSOs on the GHG inventories.

V. TIMETABLE

15. The Task Force will work for the period from January 2012 to end of 2013.

VI. METHODS OF WORK

16. The Task Force should develop a more detailed work plan at its first meeting, which will be presented to the CES Bureau. The Task Force will meet face-to-face at least once per year as agreed by the Chair and members. Much of the work is expected to be carried out electronically.

17. The Task Force should be chaired by a statistician with experience and knowledge of the issues. The Chair will have the responsibility for ensuring that the Task Force fulfils its mandate and that its composition is balanced between statisticians and other experts. A leadership sub-group from among the Task Force members will be created to assist the Chair in managing the work.

18. The UNECE will provide secretariat support to the work of the Task Force.

VII. MEMBERSHIP

19. The Task Force will be open to all CES members. International organisations, including UN bodies and other agencies are welcome to participate.

20. The work will be initiated with a small group, including the NSOs of Canada, Finland, Italy, Norway and United Kingdom, as well as EEA, Eurostat and UNSD. At the first stage, this group will focus on defining the scope of work and assessing the gap between the user needs and the available statistics.

ANNEX II
Examples of variables in selected frameworks and approaches

A. DRIVING FORCES – PRESSURE – STATE – IMPACTS – RESPONSE (DPSIR)

State:

- **Atmosphere and climate:** earth's surface and the stratosphere, air temperature, hot and cold extremes; precipitation extremes; ozone concentrations
- **Cryosphere:** glaciers, Arctic sea ice, mountain permafrost, snow cover
- **Marine biodiversity and its ecosystems:** sea level rise, sea surface temperature, storm surges, retreat of shorelines due to erosion, distribution of marine species[70]

Driving forces:

- **Population structure and movement:** Population movements, urbanization and structure of households (lower number of members).
- **Wealth and consumption:** demand for energy and transport, demand for housing (more and bigger houses occupied by smaller households, more heated houses, more household appliances), intensive agricultural practices higher levels of waste and changing diets (demand for meat, industrial scale food production, processed foods, imported foods, etc.).
- **Economic activity:** Increasing mining, manufacturing and construction, increasing GDP and higher economic growth.
- **Globalisation:** Internationalization of the economy (more global trade, outsourcing to third countries, especially "carbon leakage" in the case of more polluting industries, and tourism that increases international transportation.

Pressures:

- Combustion of fossil fuels in different industry sectors
- Production of fossil fuels
- Livestock in agriculture
- Emission factors
- Production of ozone depleting substances
- Waste treatment methods, etc.

Impact:

Impacts in terms of natural phenomena:

- **Water quantity:** water availability; extreme events/floods/ droughts and water discharge
- **Freshwater quality and biodiversity:** lake/river temperatures; lake/river ice cover; water quality; aquatic ecosystems; movements of freshwater species
- **Terrestrial ecosystems and biodiversity:** shifts in plant species northward and uphill, seasonal cycles in plants; behaviour of birds and insects, composition of ecosystems
- **Soil:** carbon sequestration in vegetation and soils; water retention capacity[71]

Socio-economic impacts on the well-being of society:

[70] These are the categories four to seven of the state and impact indicators of climate change as defined by the European Environment Agency (EEA): acm.eionet.europa.eu/reports/CC%20State%20Impact%20Indicators%20in%20Europe

[71] These are the first three categories of the state and impact indicators of climate change as defined by EEA.

a) **Agriculture and forestry:** growing season and yields of key crops; agricultural crops cycle; irrigation; pests and diseases; forest growth, forest fires
b) **Human health:** mortality due to heat-waves; hospital admissions (allergies, hay fever); distribution of vector-borne diseases (e.g. malaria and Lyme-disease) and food-/waterborne diseases; vulnerable groups
c) **Economic impacts:** insurance costs; electricity, gas and water consumption; shifts of major flows of tourism; vulnerable regions; losses resulting from weather and climate-related events in industry and transport sectors, changes in income levels and income distribution[72]

Responses:

Responses cover measures taken and are often expressed as official targets, such as, for example, the quantified emission limitations or reduction objectives under the Kyoto Protocol to the UNFCCC:

d) % reduction of greenhouse gas emissions compared with 1990 levels
e) % share of energy from renewable sources in gross final energy consumption
f) % increase in energy efficiency

Information on:

g) Economic opportunities generated, like eco-industries, green jobs and green growth
h) Community actions to mitigate the effects and adapt to climate change
i) Development of eco-friendly technology and technology exchange

B. FRAMEWORK FOR THE DEVELOPMENT OF ENVIRONMENT STATISTICS (FDES)

Environmental conditions and quality:

- **Physical conditions**: data on atmosphere, climate and weather, hydrological systems, terrestrial, marine coastal area and island characterizations, geographic information
- **Soil and Land cover:** soil characteristics (including degradation) and land cover
- **Biodiversity and ecosystems:** state of and changes in ecosystems, flora, fauna and terrestrial and marine biodiversity, forests, existence of protected areas and species, extent, localization, health, characteristics, main patterns, trends and vulnerabilities of ecosystems
- **Environmental quality:** concentrations of climate process drivers (emissions of these pollutants will be covered under component 3); biological, hydromorphological and physico-chemical parameters of fresh and marine water; and finally soil quality.

Environmental resources and their use:

- **Non-energy mineral resources:** stocks and changes (due to new discoveries, extraction, catastrophic losses, reappraisals, etc.)
- **Energy resources:** stocks and changes (due to new discoveries, extraction, catastrophic losses, reappraisals, etc.) renewable and non-renewable energy production, energy consumption
- **Land**: land use and land use change by land use category (e.g. agriculture, forestry, built up land and land used for maintenance and restoration of environmental functions with an impact to climate**)**
- **Biological resources:** stocks and changes in timber resources; changes in aquatic resources (different species) and other biological resources (flora and fauna organisms), crops and livestock
- **Water resources:** water stocks, use and returns, including in snow, ice and glaciers.

[72] These are the last three categories of the state and impact indicators of climate change as defined by EEA.

Emissions, residuals and waste:

- **Emissions to air:** GHG released to the atmosphere and consumption of ozone depleting substances (ODS).

Extreme Events and Disasters:

- **Natural extreme events and disasters:** frequency, location, intensity and impact (people affected, economic loss and ecosystem integrity) of disasters and extreme events deriving from climate change (storms, tornados, droughts, floods, extreme temperatures, mass movement, wildfires, earthquakes, volcano eruptions, tsunamis).

Human Habitat and Environmental Health:

- **Human habitat:** data on housing conditions allowing to identify houses in zones vulnerable to climate related natural disasters and extreme events, population exposed to air pollution
- **Environmental health:** data on epidemic changes (vector borne diseases) and incidences, morbidity and mortality related to climate change phenomena.

Environment protection, management and engagement:

- **Protection and resource management expenditure:** costs of mitigation and adaptation measures
- **Environmental governance and regulation:** climate change related protection measures and climate conventions; regulation (norms, environmental licensing, recycling and energy efficiency programmes, number of quotas and other restrictive production norms, per sector or economic activity), economic instruments (climate change related taxes, subsidies, eco labelling, certification and other market instruments)
- **Extreme Event Preparedness and Disaster Management**: management systems address to cope with climate change related extreme events
- **Environmental Information and Awareness**: climate change related information education and perception

C. THE SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING

(Text to be provided)

D. NATURAL CAPITAL APPROACH

Natural assets:

Ecosystems:

- **Terrestrial ecosystem**
- **Aquatic ecosystem**
- **Atmospheric ecosystem**

Land:

- **Provision of space:** dwellings, transportation infrastructure, agriculture and recreation
- **Types of land area:** land areas of specific types can be augmented or diminished as a result of climate change and changes in the way in which land is used. For example, increasing use of land for urban purposes.

Sub-soil resources:

- **Stocks of ecological goods:** for example minerals, fossil fuels and water

Ecosystem Goods and Service flows (EGS):

- The **provision of space** for human activities may be impacted by changing patterns of rainfall and temperature and by flooding of coastal areas. Currently viable agricultural land may become less productive if rainfall decreases and/or temperatures increase. Coastal areas that provide living space for millions of people and much of the world's economic activity may become less habitable.
- The **flood protection** service offered by forests and wetlands may be disrupted by changing rainfall patterns and, especially, the greater frequency of severe storms.
- Protection from the spread of **vector-borne diseases** may be hindered as changes to ecosystems allow the spread of insects and other disease-carrying organisms to areas where they did not previously exist
- The **transportation service** offered by rivers, lakes and oceans may be disrupted in places where water levels fall below historical averages as a result of decreased rainfall or where increased storms add additional risk to the use of the services. Increased rainfall leading to increased runoff and, ultimately, to increased siltation of river beds and harbours, with consequences for navigability.
- The **recreational opportunities** offered by the environment are likely to be reduced in a variety of ways. Forests, for example, may become less attractive as destinations if trees are unable to adapt quickly enough to changing conditions and die as a result. Similarly, the quality of seaside recreational experiences will decline if ocean levels rise sufficiently to flood beaches and if coral reefs die in large numbers.
- Those who appreciate the environment for its **aesthetic, cultural or existence value** may find fewer reasons to appreciate the environment for what it offers in these regards as a result of climate change.
- **Food production** may be reduced if rainfall and temperature patterns change such that agricultural land becomes less productive (the opposite may occur if unproductive land becomes productive because of warmer temperatures or increased rainfall).
- **Flows of marine resources** (seafood, etc.) may be reduced if ocean temperatures and currents change.
- Timber and other **forest product flows** may be reduced if forest ecosystems are disrupted.
- **Surface and groundwater flows** may be reduced in areas where rainfall decreases. Increased temperatures may lead to warmer surface water and increased growth of organic matter, reducing water quality even where water quantity is not affected.

The range of statistical variables:

- Capacity of natural assets to deliver EGS
- Flows of EGS from natural assets to the human sphere
- Flows of waste materials and energy from the human sphere to natural assets
- Flows related to environmental protection activities
- Flows related to substitution of other asset services for natural asset services.

E. IMPACTS, MITIGATION AND ADAPTATION

Impacts:

- **Consequences** of climate change: the impacts from the changing climate in terms of natural impacts (e.g. heat waves, rising oceans, glaciers retreats, droughts, etc.) and the socio-economic impacts (e.g. reduced crop yields, changes in crop patters, changes in disease patters, etc.).

Adaptation:

- **Actions and measures** taken to adapt to the inevitable consequences of climate change as far as they are statistically quantifiable: measures typically listed in so called National Adaptation Strategies may not always be expressed in quantifiable terms. For example, educational work is important for effective adaptation.

Mitigation:

- **Efforts to control the causes** of climate change: the greenhouse gas emissions and all the underlying activities behind them (e.g. the activities in the different inventory sectors such as energy, industrial processes, agriculture, waste, etc.) as well as the broader socio-economic phenomena such as population growth, urbanisation, industrialisation, etc. that have an impact on increased emissions. Mitigation also includes the measures taken to address these causes, i.e. any emission reduction action which can be statistically quantified (e.g. energy taxes, transport taxes, data on the carbon market and trade, renewable energy resources, etc.).

ANNEX III
Coverage of statistical topics by the frameworks and approaches

Summary table

Statistical area	Frameworks						Relevance
Demographic and social statistics	**DPSIR**	**FDES**	**IPCC**	**SEEA**	**Capital**	**IMA**	**Related**
1.1 Population and migration	x	x	x			x	related
1.2 Labour	partly						indirectly
1.3 Education	x	x	x			x	indirectly
1.4 Health	x	x	x		partly	x	**closely**
1.5 Income and consumption	x	partly	partly			x	related
1.6 Social protection	partly					x	indirectly
1.7 Human settlements and housing	x	x	x		x	x	**closely**
1.8 Justice and crime							indirectly
1.9 Culture			x		partly		indirectly
1.10 Political and other community activities	x	partly	x			x	indirectly
1.11 Time use	x		x		partly	x	**closely**

Statistical area	Frameworks						Relevance
Economic statistics	**DPSIR**	**FDES**	**IPCC**	**SEEA**	**Capital**	**IMA**	**Related**
2.1 Macroeconomic statistics	x					x	indirectly
2.2 Economic accounts	x				x	x	indirectly
2.3 Business statistics	partly	partly	partly		x	partly	indirectly
2.4 Sectoral statistics							
2.4.1 Agriculture, forestry, fisheries	x	partly	partly		x	x	**closely**
2.4.2 Energy	x	partly	partly		x	x	**closely**
2.4.3 Mining, manufacturing, construction	x	partly	partly		x	x	**closely**
2.4.4 Transport	x	partly	partly		x	x	**closely**
2.4.5 Tourism	x	x			x	x	**closely**
2.4.6 Banking, insurance, financial statistics	partly	partly				partly	indirectly
2.5 Government finance, fiscal, public sector	partly	partly	partly			partly	indirectly
2.6 International trade, balance of payments	x		x		x	partly	indirectly
2.7 Prices	x					x	indirectly
2.8 Labour cost							indirectly
2.9 Science, technology and innovation	x		x			x	related

Statistical area	Frameworks						Relevance
Environment and multi-domain statistics	**DPSIR**	**FDES**	**IPCC**	**SEEA**	**Capital**	**IMA**	**Related**
3.1 Environment	x	x	x		x	x	**closely**
3.2 Regional and small area statistics	x	x	x		x	x	**closely**
3.3 Multi-domain statistics and indicators							
3.3.1 Living conditions, poverty, social issues	x	x	x		partly	x	related
3.3.2 Gender and special population groups	x	partly	x		partly	x	related
3.3.3 Information society							indirectly
3.3.4 Globalisation	x		x		partly	partly	related
3.3.5 Millennium Development Goals	partly	partly	partly		partly	partly	related
3.3.6 Sustainable development	x	x	x		x	x	**closely**
3.3.7 Entrepreneurship	partly	partly	partly		partly	partly	related

Issues covered by the different frameworks and approaches

	DPSIR	FDES	IPCC	SEEA	Capital	Mitigation-adaptation
Demographic and social statistics						
1.1 Population and migration	**Drivers:** population and migration movements	**Human habitat:** total population	**Socio-economic development:** population		-	**Mitigation:** of population growth, urbanization **Adaptation:** migration movement
1.2 Labour	**Responses:** green jobs	-	-		-	-
1.3 Education	**Responses:** climate related education	**Environment protection:** climate related information education and awareness	**Socio-economic development:** literacy		-	**Adaptation:** education to cope with changing climate
1.4 Health	**Impact:** climate related mortality, allergies, hay fever, vector-borne diseases, food-/waterborne diseases	**Human habitat:** Water related, airborne and vector-borne diseases, UV and pollution exposure, morbidity and mortality	**Impacts and vulnerability:** impacts on human health; **Socio-economic development:** Health		**EGS flows:** disrupted protection from vector-borne diseases	**Adaptation:** to changes in health environment due to climate change
1.5 Income and consumption	**Drivers:** level of wealth, consumption, **Impact:** electricity, gas and water consumption, changes in income distribution, economic losses	**Extreme events:** economic losses due to disasters; **Environmental resources:** as a source of income and consumption habits	**Socio-economic development:** consumption patterns		-	**Adaptation:** changes in income and consumption due to climate change
1.6 Social protection	**Responses:** protection of vulnerable	-	-		-	**Adaptation:** actions taken for social protection

	groups/regions, finance					
1.7 Human settlements and housing	**Drivers:** urbanisation, structure of households, demand for housing; **Impact:** heating days, economic losses, disasters	**Emissions and waste:** greenhouse gas emissions, generation of waste; **Extreme events:** economic losses due to disasters; **Human habitat:** pressure from built environment, living conditions	**Impacts and vulnerability:** settlements and society		**EGS flows:** changes in the provision of space, in flood protection, in the recreational opportunities and cultural value of environment	**Mitigation:** urbanization
1.8 Justice and crime	-	-	-		-	-
1.9 Culture	-	-	**Socio-economic development:** socio-cultural preferences		**EGS flows:** changes in the aesthetic, cultural and existence value of environment	-
1.10 Political and other community activities	**Responses:** political measures, adaptation and mitigation, financing	**Environmental protection:** environmental governance and protection activities	**Socio-economic development:** governance, mitigation, adaptation		-	**Mitigation:** energy taxes, transport taxes, data on the carbon market and trade, renewable energy resources
1.11 Time use	**Drivers:** changing habits and diets	-	**Socio-economic development:** socio-cultural preferences		**EGS flows:** changes in recreational use and attractiveness of environment	**Adaptation:** changes in time use to adapt to climate change
Economic statistics						
2.1 Macroeconomic statistics	**Drivers:** level of economic activity, GDP	-	-		-	**Mitigation:** level of economic activity

2.2 Economic accounts	**Drivers:** level of economic activity by sectors, **Impact:** changes in economic activity by sector/industry	-	-		-	**Mitigation:** level of economic activity; **Adaptation:** changes in activity of industries
2.3 Business statistics	**Impact:** economic performance, economic opportunities and limitations, eco-industries	**Environmental resources and use:** land use, timber resources, crops, livestock **Emissions and waste:** greenhouse gas emissions, generation of waste; **Extreme events:** losses of revenue due to disasters	**Socio-economic development:** production patterns		**Natural assets:** availability of inputs and raw material	**Mitigation:** eco-industries, environment friendly technologies; **Adaptation:** finding new economic opportunities, adaptation to economic limitations
2.4 Sectoral statistics						
2.4.1 Agriculture, forestry, fisheries	**Drivers:** agricultural practices, demand for meat; **Pressures:** livestock in agriculture, production of fossil fuels, forestry and land use, greenhouse gas emissions; **Impact:** growing season and crop yields, irrigation, pests and diseases, forest growth, fires, losses from climate-related events	**Environmental resources and use:** land use, timber resources, crops, livestock **Emissions and waste:** greenhouse gas emissions, generation of waste; **Extreme events:** economic losses, crop losses and damage due to disasters	**Climate process drivers:** greenhouse gas emissions		**Natural assets:** degradation leading to changes in ecosystems and in the distribution of and quality of different types of land and forests; **EGS flows:** changes in timber and other forest product flows	**Mitigation:** reduction of greenhouse gas emissions, renewable energy resources; measures to mitigate these; **Adaptation:** to reduced crop yields, changes in crop patters and seasons, crop varieties, forest fires

2.4.2 Energy	**Drivers:** demand for energy and heating; **Pressures:** production of fossil fuels, greenhouse gas emissions; **Responses:** energy, material and emissions efficiency	**Environmental resources and use:** production of energy (renewable and non-renewable), energy consumption; **Emissions and waste:** greenhouse gas emissions, generation of waste; **Extreme events:** economic losses due to disasters	**Climate process drivers:** greenhouse gas emissions		**Natural assets:** changes in the energy resources and sub-soil resources; **EGS flows:** changes in flows of waste and energy, and inputs to industrial processes and home heating	**Mitigation:** reduction of greenhouse gas emissions, use of the carbon market and trade, renewable energy resources; **Adaptation:** in energy demand and use
2.4.3 Mining, manufacturing, construction	**Drivers:** mining, manufacturing and construction levels, changes in food production; **Pressures:** production of fossil fuels, greenhouse gas emissions, production of ozone depleting substances; **Impact:** economic losses from climate-related events	**Environmental resources and use:** minerals; **Emissions and waste:** greenhouse gas emissions, generation of waste; **Extreme events:** economic losses due to disasters	**Socio-economic development:** production patterns; **Climate process drivers:** greenhouse gas and aerosol emissions		**Natural assets:** changes in the sub-soil resources, mineral, liquids and gases and sub-soil resources; **EGS flows:** changes in inputs to industrial processes and construction	**Mitigation:** reduction of greenhouse gas emissions, use of the carbon market and trade, renewable energy resources; **Adaptation:** in energy demand and use
2.4.4 Transport	**Drivers:** demand for transport; **Pressures:** production of fossil fuels, greenhouse gas emissions; **Impact:** economic losses from climate-related events	**Environmental resources and use:** pressures on the climate	**Climate process drivers:** greenhouse gas emissions		**Natural assets:** changes in the provision of space; **EGS flows:** changed transportation services of waters and atmosphere	**Mitigation:** reduction of greenhouse gas emissions, renewable energy resources
2.4.5 Tourism	**Drivers:** levels of tourism, demand for	**Emissions and waste:** greenhouse gas	-		**EGS flows:** changes in the attractiveness of	**Mitigation:** reduction of greenhouse gas emissions;

	transport **Pressures:** production of fossil fuels, greenhouse gas emissions; **Impact:** shifts of tourism flows, economic losses from climate-related events	emissions, generation of waste; **Extreme events:** economic losses due to disasters			destinations for tourism, and in the aesthetic, cultural and existence value	**Adaptation:** changes in tourism flows
2.4.6 Banking, insurance, financial statistics	**Impact:** insurance costs; **Responses:** financial costs of responses and protection	**Environment protection:** climate protection expenditure	-		-	**Mitigation:** financial tools; **Adaptation:** costs of adaptation
2.5 Government finance, fiscal and public sector	**Responses:** financing and government measures in adaptation and mitigation	**Environment protection:** climate protection and management expenditure, regulation related to climate, participation in climate conventions	**Socio-economic development:** governance, mitigation, adaptation		-	**Mitigation:** using financial and legislative tools, governance; **Adaptation:** of legislation and institutional mechanisms, adaptation measures
2.6 International trade and balance of payments	**Drivers:** Internationalisation of the economy, carbon leakage	-	**Socio-economic development:** trade		**EGS flows:** changed transportation services	**Mitigation:** responsible trade
2.7 Prices	**Responses:** energy prices, oil prices and others	-	-		-	**Adaptation:** through changes in pricing
2.8 Labour cost	-	-	-		-	-

2.9 Science, technology and innovation	-	**Responses:** eco-friendly technology development and technology exchange	**Socio-economic development:** technology		-	**Mitigation and adaptation:** through technology transfer and capacity building
Environment and multi-domain statistics						
3.1 Environment	**State:** atmosphere and climate, cryosphere, marine biodiversity and its ecosystems; **Drivers:** waste from production and consumption **Pressures:** combustion of fossil fuels, waste treatment methods, greenhouse gas emissions; **Impact: w**ater quantity, freshwater quality and biodiversity, terrestrial ecosystems and biodiversity, soil, access to water; **Responses:** reduction of emissions, renewable energy, energy efficiency, environmental protection expenditure, recycling and waste, environment taxes and subsidies, permits and certificates	**Environmental conditions:** atmosphere, climate, weather; hydrographic issues, geological and geographic conditions, soil characteristics, land cover, biodiversity, ecosystems, forests; air, freshwater and marine water quality; **Environmental resources and use:** aquatic and water resources, use and returns of water; **Emissions and waste:** greenhouse gas emissions, wastewater, generation of waste, waste management; **Extreme events:** occurrence of disasters; **Human habitat:** urban environmental concerns; **Environment protection:** protection	**Climate change:** temperature change, precipitation change, sea level rise and extreme events; **Impacts and vulnerability:** Impacts on ecosystems and water resources; **Climate process drivers:** greenhouse gas and aerosol emissions and concentrations		**Natural assets:** changes in ecosystems, land and sub-soil resources; **EGS flows:** provision of space, flood protection service of forests and wetlands, transportation services by waters, recreational opportunities and aesthetic, cultural and existence value, marine resources	**Adaptation:** to heat waves, rising oceans, glaciers retreats, droughts, seasonal changes, different variety of species, water supply changes, new crop varieties, changes in ecosystems including biodiversity and ecosystem goods and services; **Mitigation:** of the adverse impacts of the above changes

		expenditure, regulation, conventions, measures taken and education				
3.2 Regional and small area statistics	**Impact:** extreme events, regional impacts on environment, agriculture, economy and humans; **Responses:** regional measures	**Extreme events:** occurrence of disasters, people affected by disasters; **Human habitat:** location of habitats, specific concerns of urban habitat, vulnerable groups	**Impacts and vulnerability:** regional impacts on ecosystems and water resources, settlements, society, food security and human health		**Natural assets:** changes in ecosystems, land and sub-soil resources; **EGS flows:** food production, space at coastal areas, floods	**Mitigation:** of the impacts of extreme events; **Adaptation:** to changed local conditions
3.3 Multi-domain statistics and indicators						
3.3.1 Living conditions, poverty and cross-cutting social	**Drivers:** level of wealth, consumption habits, **Impact:** electricity, gas and water consumption, changes in income distribution, economic losses	**Human habitat:** access to water, sanitation and energy; specific concerns of urban habitat, green areas	**Impacts and vulnerability:** impacts on human settlements and society; **Socio-economic development:** socio-cultural preferences, equity		**EGS flows:** food production, marine resources, forest products, space, floods, transportation services, recreation, aesthetic, cultural or existence value of environment	**Mitigation:** against hunger and poverty; **Adaptation:** to changed environmental conditions and changes in income distribution
3.3.2 Gender and special population groups	**Impact:** vulnerable groups, redistribution of wealth; **Responses:** social protection and financing	**Human habitat:** vulnerability to disasters	**Impacts and vulnerability:** impacts on vulnerable settlements, society, food security and human health; **Socio-economic development:** equity		**EGS flows:** food production, space at coastal areas, floods	**Mitigation:** against adverse effects of climate change towards vulnerable population groups; **Adaptation:** to changed conditions

3.3.3 Information society	-	-	-		-	-
3.3.4 Globalisation	**Drivers:** Internationalisation of the economy, carbon leakage	-	**Socio-economic development:** changes in trade patterns		**EGS flows:** changes in transportation services	**Mitigation:** responsible trade
3.3.5 Indicators related to Millennium Development Goals	**Impact & responses:** links to MDG1 on poverty, MDG6 on diseases, MDG7 on environmental sustainability	**Human habitat:** links to MDG6 on diseases, MDG7 on environmental sustainability	**Socio-economic development:** links to MDG1 on poverty, MDG6 on diseases, MDG7 on environmental sustainability		**Natural assets and EGS flows:** link to MDG1 on poverty, MDG6 on diseases, MDG7 on environmental sustainability	**Mitigation and adaptation:** link to MDG1 on poverty, MDG6 on diseases, MDG7 on environmental sustainability
3.3.6 Sustainable development	**Responses:** links to sustainable development, e.g. through reduction of emissions, renewable energy, energy efficiency, environmental protection, recycling, environment taxes and subsidies, permits and certificates, green growth and green jobs	**Environmental resources and use:** sustainable use of natural resources; **Environmental protection:** sustainable use of natural resources related to climate	**Impacts and vulnerability:** impacts on ecosystems; **Socio-economic development:** governance, mitigation		**Natural assets:** level of sustainable use of natural assets	**Mitigation:** measures in support of sustainable development, environmental protection, taxes and subsidies, permits and certificates, green jobs
3.3.7 Entrepreneurship	**Drivers:** economic growth **Impact:** economic performance, limits, opportunities, eco-industries	**Extreme events:** losses of revenue due to disasters	**Socio-economic development:** opportunities of technology exchange		**Natural assets:** availability of inputs and raw material	**Mitigation:** eco-industries, environment friendly technologies; **Adaptation:** economic opportunities, adaptation to limitations

ANNEX IV

Tool for reviewing sectoral details, methodologies and data sources of the greenhouse gas inventory (example by the United Kingdom)

Data categories			Methodology	Summary of activity/ emissions data sources	Status of underlying data					
National Communication		IPCC								
Category	Name				Published as Official Statistics	Official Statistics, but with further disaggregation needed	Publicly available, but not as Official Statistics	Based on non-public data which is specifically requested	Commercially confidential	Based on other published research
Energy Supply	Power Stations	1A1a	Emission factor * activity	Digest of UK energy statistics (DUKES), plant operator and EU Emissions Trading System (EUETS) data	Partly	Partly		Partly	Partly	
	Refineries	1A1b	Emission factor * activity	DUKES, plant operator and EUETS data	Partly	Partly			Partly	
	Manufacture of solid fuels and other energy industries	1A1c	Emission factor * activity	DUKES	Yes					
	Coal mining and handling	1B1a	Emission factor * activity	DUKES	Yes					
		1B1c	Modelled	WSP-consultancy						Yes
	Solid fuel transformation	1B1b	Carbon balance approach	DUKES	Yes					

	Exploration, production and transport of oils	1B2a	Emission factor * activity; operator reported emissions	DUKES and Environmental Emissions Monitoring System (EEMS)	Partly	Partly			Partly	
	Offshore oil and gas - Flaring	1B2cii	Operator reported emissions	EEMS					Yes	
	Offshore oil and gas - Venting	1B2ci	Operator reported emissions	EEMS					Yes	
	Power stations - FGD	2A3	Emission factor * activity	UK Minerals Yearbook and Pollution Inventory data			Yes			
	Exploration, production and transport of gas	1B2b	Modelled (natural gas leakage); operator reported emissions (offshore activities)	Gas operators, EEMS				Yes		
Business	Iron and steel - combustion and electricity	1A2a	Emission factor * activity	DUKES	Yes					
	Other industrial combustion and electricity	1A2b	Emission factor * activity	DUKES	Yes					
		1A2c	Emission factor * activity	DUKES	Yes					
		1A2d	Emission factor * activity	DUKES	Yes					
		1A2e	Emission factor * activity	DUKES	Yes					
		1A2f	Emission factor * activity (stationary sources); modelled (mobile sources)	DUKES, Plant operators and industry data, Ricardo-AEA consultancy off road model	Partly					Partly
	Miscellaneous industrial and commercial combustion and electricity	1A4a	Emission factor * activity	DUKES	Yes					
	Energy recovery from waste fuels	2B5	Emission factor * activity	Pollution Inventory; British Cement Association (BCA)			Partly		Partly	

	Refrigeration and air conditioning	2F1	Modelled	Model updated by International Climate Fund (ICF), using literature sources and consultation with industry. Verified against sales data from the British Refrigeration Association.					Partly	Partly
	Foams	2F2	Modelled	Estimates supplied by Caleb Management Services						Yes
	Firefighting	2F3	Modelled	March (1999), Fire Industry Council, updated based on stakeholder consultation with ASSURE Property Inventory Services						Yes
	Solvents	2F5	Modelled	Harnisch and Schwarz, 2003						Yes
	One Component Foams	2F9	Modelled	Harnisch and Schwarz, 2003						Yes
	Electronics, electrical insulation and sporting goods	2F9	Modelled	Microelectronics Environmental Advisory Committee (UKMEAC) (semiconductors); BEAMA (representing equipment manufacturers) and the Electricity Association (electrical equipment); Sales data reported by the manufacturer (sporting goods);					Partly	Partly
Transport	Civil aviation (Domestic, Cruise)	1A3a	Model based on CAA data and DUKES	Civil Aviation Authority, DUKES		Yes				
	Civil aviation (Domestic, Landing and take off)	1A3a	Model based on CAA data and DUKES	Civil Aviation Authority, DUKES		Yes				
	Passenger cars	1A3b	Modelled	DUKES, Department for Transport (DfT)		Yes				
	Light duty vehicles	1A3b	Modelled	DUKES, DfT		Yes				
	Buses	1A3b	Modelled	DUKES, DfT		Yes				
	HGVs	1A3b	Modelled	DUKES, DfT		Yes				
	Mopeds & motorcycles	1A3b	Modelled	DUKES, DfT		Yes				
	LPG emissions (all vehicles)	1A3b	Modelled	DUKES, DfT		Yes				
	Other (road vehicle engines)	1A3b	Modelled	DUKES, DfT		Yes				
	Railways	1A3c	Emission factor * activity	Translink LGDC, Office of Rail Regulation (ORR) National Rail Trends Yearbook			Partly	Partly		

	Railways - stationary combustion	1A4a	Emission factor * activity	DUKES	Yes					
	National navigation	1A3d	Emission factor * activity	DUKES, Entec (2010)	Partly					Yes
	Fishing vessels	1A4c	Emission factor * activity	Entec shipping study, Carbon factors review, European Monitoring and Evaluation Programme (EMEP/Corinair) Guidebook						Yes
	Military Aircraft and shipping	1A5b	Emission factor * activity	Civil Aviation Authority (CAA), Ministry of Defence (MOD)				Yes		
	Aircraft Support Vehicles	1A3e	Modelled	DUKES; Ricardo-AEA off road model						Yes
Public	Public	1A4a	Emission factor * activity	DUKES	Yes					
Residential	Residential combustion	1A4b	Emission factor * activity	DUKES	Yes					
	Use of non-aerosol consumer products	2B5	Emission factor * activity	DUKES; Sales data from Cosmetic, Toiletry & Perfumery Association (CTPA)			Yes			
	Accidental vehicle fires	6C	Emission factor * activity	Ricardo-AEA estimate based on CLG fire statistics	Yes					
	Aerosols and metered dose inhalers	2F4	Modelled	British Aerosols Manufacturers Association; methylene diphenyldiisocyanate (MDI) Import/Export data from manufacturers				Yes		
Agriculture	Stationary and mobile combustion	1A4c	Emission factor * activity (stationary sources); modelled (mobile sources)	DUKES, Ricardo-AEA estimates	Partly					Partly
	Breakdown of pesticides	2B5	Emission factor * activity	British Agrochemicals Association, Crop Protection Association			Yes			
	Enteric Fermentation - Cattle	4A1	Tier 2 Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Enteric Fermentation - Sheep	4A3	Tier 2 Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Enteric Fermentation - Goats	4A4	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Enteric Fermentation - Horses	4A6	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Enteric Fermentation - Swine	4A8	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					

	Enteric Fermentation - Deer	4A10	Tier 2 Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Cattle	4B1	Tier 2 Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Sheep	4B3	Tier 2 Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Goats	4B4	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Horses	4B6	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Swine	4B8	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Poultry	4B9	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Deer	4B10	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Manure Liquid Systems	4B12	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Solid Storage and Dry Lot	4B13	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Wastes - Other manure management (N2O)	4B14	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Direct Soil Emission	4D	Emission factor * activity	Defra Economics and Statistics Group - June Census and Devolved Administrations	Yes					
	Field burning of agricultural wastes	4F1	Emission factor * activity	Estimates compiled by Rothamsted Research	Yes					
		4F5	Emission factor * activity	Estimates compiled by Rothamsted Research	Yes					
Industrial Process	Sinter production	1A2a	Carbon balance approach	DUKES	Yes					
	Cement production	2A1	Emission factor * activity	UK Minerals Yearbook, British Cement Association, EU ETS			Partly		Partly	
	Lime production	2A2	Emission factor * activity	UK Minerals Yearbook, EU ETS			Partly		Partly	
	Limestone and dolomite use	2A3	Emission factor * activity	ISSB Annual Statistics and Industry data				Yes		

		2A7	Emission factor * activity	Ricardo-AEA estimate based on industry data				Yes		
	Soda ash production and use	2A7	Emission factor * activity	Ricardo-AEA estimate based on industry data				Yes		
	Fletton bricks	2A7	Calculated, based on operator reported emissions data and brick production statistics	Ricardo-AEA estimate based on ONS data; Pollution Inventory	Partly		Partly			
	Ammonia production	2B1	Calculated, based on operator reported data on CO_2 produced, emitted and sold.	Plant Operators data				Yes		
	Iron and steel production	2C1	Carbon balance approach	DUKES, International Steel Statistics Bureau (ISSB) Annual Statistics	Partly		Partly			
	Aluminium production	2C3	Emission factor * activity; operator reported data	UK Minerals yearbook, Ricardo-AEA estimates, Pollution Inventory			Yes			
	Nitric acid production	2B2	Operator reported data	Plant Operators data, Pollution Inventory				Yes		
	Adipic acid production	2B3	Operator reported data	Industry data, via personal communication					Yes	
	Other - Chemical industry	2B5	Calculated, based on operator reported emissions and plant capacity data.	Ricardo-AEA estimates based on plant capacity and data reported to the Pollution Inventory			Yes			
	Halocarbon production	2E1	Operator reported data	Data reported via the Pollution Inventory and direct to Ricardo-AEA			Partly		Partly	
		2E2	Operator reported data	Data reported via the Pollution Inventory and direct to Ricardo-AEA			Partly		Partly	
	Magnesium cover gas	2C5	Modelled; Operator reported data	Data reported via the Pollution Inventory and direct to Ricardo-AEA			Partly	Partly		
Land Use Change	Forest Land remaining Forest Land	5A1	Modelled							Yes

	Biomass burning (Forest Land)	5A	Modelled							Yes
	Land converted to forest land	5A2	Modelled							Yes
	Direct N_2O emission from N fertilisation of forest land	5A2	Modelled							Yes
	Drainage of Organic Soils (Forest Land)	5A	Modelled							Yes
	Biomass burning (Cropland)	5B	Modelled							Yes
	Liming (Cropland)	5B1	Modelled							Yes
	Cropland remaining cropland	5B1	Modelled							Yes
	Land converted to cropland	5B2	Modelled							Yes
	N_2O emissions from disturbance associated with land-use conversion to cropland	5B2	Modelled							Yes
	Biomass burning (Grassland)	5C	Modelled							Yes
	Liming (Grassland)	5C1	Modelled							Yes
	Grassland remaining grassland	5C1	Modelled							Yes
	Land converted to grassland	5C2	Modelled							Yes
	Wetlands remaining Wetland	5D1	Modelled							Yes
	Non-CO2 emissions from drainage of soils and wetlands	5D2	Modelled							Yes
	Land converted to Wetland	5D2	Modelled							Yes
	Settlements remaining settlements	5E1	Modelled							Yes

	Biomass burning (Settlements)	5E	Modelled							Yes
	Land converted to settlements	5E2	Modelled							Yes
	Harvested wood	5G	Modelled							Yes
Waste Manage-ment	Landfill	6A1	Modelled	Methane emissions from landfill using MELMod-UK model						Yes
	Waste-water handling	6B1	Emission factor * activity	Defra, IPCC Defaults	Yes					
		6B2	Modelled	Office for National Statistics (ONS); Defra; water companies, The Water Services Regulation Authority (OFWAT)	Partly		Partly	Partly		
	Waste Incineration	6C	Emission factor * activity	Her Majesty's Inspectorate of Prisons (HMIP), DECC, Pollution Inventory			Yes			

ANNEX V
European Statistical System (ESS) quality criteria for statistical output compared to the criteria for greenhouse gas inventories

ESS criteria[73]	IPCC guidelines
Relevance is the degree to which statistics meet current and potential users' needs. It refers to whether all statistics that are needed are produced and the extent to which concepts used (definitions, classifications etc.) reflects user needs.	-
Accuracy and reliability: In a statistical sense, refers to the closeness of the statistical data to the (in general) unknown true or exact value of the measured phenomena. Usually this closeness can be measured by using statistical indicators such as bias and variability of the statistical data.	*Accuracy* is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies should be used, in accordance with the IPCC good practice guidance, to promote accuracy in inventories
Timeliness and punctuality Punctuality refers to the time lag between the release date of data and the target date when it should have been delivered, for instance, with reference to dates announced in some official release calendar, laid down by Regulations or previously agreed among partners. Timeliness of information reflects the length of time between its availability and the event or phenomenon it describes	-
Accessibility and clarity Accessibility refers to the physical conditions in which users can obtain data: where to go, how to order, delivery time, clear pricing policy, convenient marketing conditions (copyright, etc.), availability of micro or macro data, various formats (paper, files, CD-ROM, Internet…), etc. Clarity refers to the data's information environment whether data are accompanied with appropriate metadata, illustrations such as graphs and maps, whether information on their quality also available (including limitation in use…) and the extent to which additional assistance is provided by the NSO.	*Transparency* means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information

[73] Quality Assurance Framework of the European Statistical System: epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/QAF_2012/EN/QAF_2012-EN.PDF

Coherence and comparability Coherence of statistics is their adequacy to be reliably combined in different ways and for various uses. It is, however, generally easier to show cases of incoherence than to prove coherence. Comparability aims at measuring the impact of differences in applied statistical concepts and measurement tools/procedures when statistics are compared between geographical areas, non-geographical domains, or over time. We can say it is the extent to which differences between statistics are attributed to differences between the true values of the statistical characteristic. There are three main approaches under which comparability of statistics is normally addressed: comparability over time, between geographical areas, and between domains.	*Consistency* means that an inventory should be internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the IPCC Good Practice *Comparability* means that estimates of emissions and removals reported by Annex I Parties in inventories should be comparable among Annex I Parties. For this purpose, this Annex should use the methodologies and formats agreed by the COP for estimating and reporting inventories. The allocation of different source/sink categories should follow the split of *the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, at the level of its summary and sectoral tables
-	*Completeness* means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC Guidelines as well as other existing relevant source/sink categories which are specific to individual Annex I Parties and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks of an Annex I Party