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14

Population Data for Climate Change Analysis

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Multiple Data for Climate Mitigation and Adaptation Analysis

Climate change analysis covers a myriad of complexities related to definition issues (e.g., the categorization of urban/rural areas); temporal and spatial scales (global, regional, national and community); the measurement of consumption-based versus supply-based emissions; definitions of basic information such as coastlines and boundaries; and omissions in the production and dissemination of statistical data, among many others. Data on population are at the centre of most of the climate-change analysis to be carried out, including climate scenarios, as well as of analyses of vulnerability, impacts and adaptation. Population, as both a driver and a subject of climate change, is part of the issue, but it is also part of the solution through actions that societies and individuals can take for mitigation and adaptation.

From previous global assessments, it appears that responses to the challenges of climate change require the use of multiple sets of data for multiple types of analyses of both the mitigation and the adaptation dimensions. Therefore, one of the foremost challenges in understanding the linkages between population dynamics and climate change lies in identifying, collecting and integrating data on multiple thematic, temporal and spatial scales.

A community of researchers is working on the integration of satellite imagery, climate modelling and socio-demographic data in order to understand local vulnerability in many parts of the world. These efforts, however, are under-funded and are being carried out with less than optimal coherence and coordination within the United Nations system to have a holistic global picture.

United Nations support for improved data streams and technical assistance are essential for making these connections. United Nations agencies must advocate for responses that include the characterization of population trends and support the data collection, research and analysis at the global and country levels that are necessary to ensure that policy responses are evidence-based. Encouraging and supporting the timely release of high-quality census data is also an important role for global institutions.

Access to global data has improved significantly in recent years, mainly in response to the development of global integrated environment assessments. Several data portals at the United Nations, the United Nations Environment Programme (UNEP), the World Bank, the Food and Agriculture Organization, etc. provide very valuable data sets at the country and regional levels. As the global picture is becoming clearer, more detailed and local information is now required in order to design appropriate concrete mitigation and adaptation measures.

This chapter will briefly review the main data needs already identified in existing assessment reports before addressing the definitional, spatial and temporal aspects of population data in a wider setting of climate-change analysis.

Overview of Climate-related Data Issues

Mitigation and adaptation data

The issue of climate change has now moved to the top of the environmental policy agenda. The entire United Nations system is committed to supporting Member States as an effective, inclusive and credible partner in mitigating and adapting to climate change. Thus, mitigation and adaptation to climate change have become global priorities. UNEP certainly is no exception to that. With the release of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) and the Bali Action Plan adopted by the United Nations Framework Convention on Climate Change's (UNFCCC) Conference of the Parties 13, UNEP was able to finalize its Medium Term Strategy (MTS) with six thematic priorities topped by climate change. Several other priority areas are very much related to climate change, such as ecosystem management, disasters and conflict, resource efficiency and environmental governance. Four major themes related to climate change were identified: adaptation, mitigation, science and communication.

While population is a major driving force of climate change, it receives relatively little attention and is often treated as an external factor. There is, however, an upstream relationship between population and climate change: More people mean more emissions, more production and more consumption. Most rapidly growing populations currently have very low per capita greenhouse gas emissions, but per capita emissions and populations are increasing rapidly in much of the world, and the developing world is becoming a substantial contributor to climate change. While industrialized countries have contributed the most to the accumulation of emissions in the atmosphere, emissions in the developing world will grow significantly faster in coming decades—because of population growth, economic growth, a high dependence on fossil fuels and a relatively high energy intensity:[1] "[T]the effect on global emissions of the decrease in global energy intensity (-33%) during 1970 to 2004 has been smaller than the combined effect of global income growth (77%) and global population growth (69%); both drivers of increasing energy-related CO_2 emissions" (IPCC, 2007).

Table 14.1: Requirements for Mitigation and Adaptation

Climate-change mitigation data needs

General	GHG emission trends (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6);
	Population, urban and rural, poverty, migration.
	Land-cover and land-use change, land degradation.
	Gross domestic product (GDP)/Purchasing power parity (PPP), sector value added, household consumption.
Energy	Energy use, supply and intensity (by sector), production and use of renewable energy (solar, wind, hydro, geothermal, biofuels), nuclear power, natural gas, coal, oil, gas.
Transport	Number of hybrid and cleaner diesel vehicles, transport volume by rail/road/water/air/non-motorized.
Buildings	Use of energy-saving bulbs, improved cook stoves, isolation.
Industry	Material recycling and substitution rates, heat and power recovery, etc.
Agriculture	Afforestation, reforestation, forest management, avoided deforestation, harvested wood product management.
Waste management	Landfill methane recovery, composting of organic wastes, waste disposal, treatment and recycling, waste water treatment.
Policies	Climate policies and measures, carbon prices, emission trading, budgets and expenditures for climate policies, meteorological monitoring.

Climate-change adaptation data needs

Water	Water availability and droughts in tropics, high latitudes, mid-latitudes and semi-arid low latitudes;
	Number of people exposed to (increased) water stress.
Ecosystems	Number and risk of extinction.
	Coastal wetlands, coastal areas.
	Coral bleaching.
	Species range shifts and wildfire risk.
Food	Productivity of cereals at low-mid-high altitudes;
	Local impacts on small holders, subsistence farmers and fishers.
Coasts	Number of people exposed to coastal flooding each year.
	Damage from floods and storms.
	Average rate of sea level rise.
Health	Changed distribution of some disease vectors;
	Burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases.
	Morbidity and mortality from heat waves, floods and droughts.
	Burden on health services (expenditures).

Source: IPCC, 2007.

There are also downstream relationships, through the link between poverty and vulnerability to the effects of climate change, changes in water supply and availability, internal and cross-border migration and potential conflicts and disasters.

In order to assess climate change mitigation and adaptation opportunities, and address the interlinkages, a whole range of scientific data and indicators are needed. The requirements for mitigation and adaptation specified in the IPCC Fourth Assessment Report (AR4) are presented in Table 14.1 (IPCC, 2007).

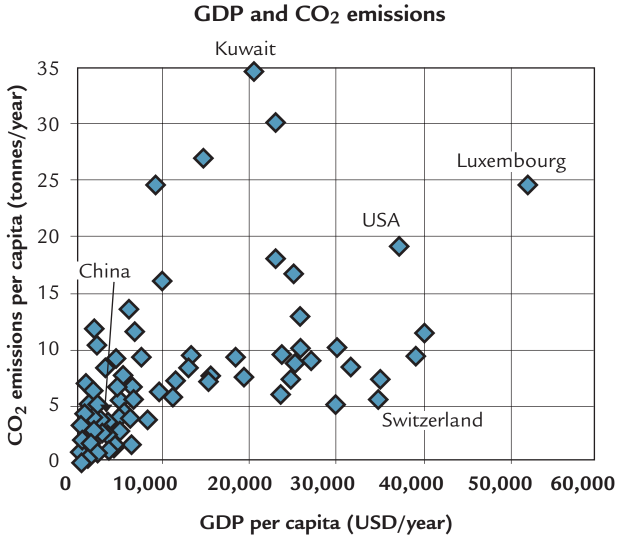
Many of the worldwide climate-related data and indicators are collected through scientific measurements, e.g., temperature, precipitation, radiation and so forth. Others are compiled by international agencies on the basis of statistical surveys, often using national statistical sources and, more recently, remote sensing data. This is the case, for example, for population (United Nations Population Division), gross domestic product (United Nations Statistics Division [UNSD] and the World Bank), forestry and agriculture (FAO), health (World Health Organization [WHO]) and energy (International Energy Agency [IEA]), among others.

But various additional data need to be collected and/or compiled to adequately address climate-change adaptation and mitigation issues. The list of these data and indicators, for which national statistical offices can play a role in regularly collecting information, includes:

- Air emissions reporting, most notably in developing ('non-Annex 1') countries, and including underlying energy and activity data;
- Data on infrastructure development (roads, etc.) and the amount of building (housing, offices, industrial plants, etc.);
- Use of renewable energy sources;
- Use of energy-saving technology (bulbs, building insulation, hybrid cars, etc.);
- Eco-labelling and use of certified products (such as certified wood);
- Use of emissions trading and climate compensation schemes (including carbon pricing);
- Volume data on transport modes (motorized and non-motorized);
- Material recycling and substitution;
- Water use;
- Land/vegetation cover and ecosystem areas (wetlands, coasts);
- Species extinction, migration patterns;
- Harvest and crop production (wheat, maize, rice, etc.);
- Mortality and morbidity (specific diseases);
- Number and extent of hydro-meteorological disasters (floods, fires, storms, droughts, heat and cold waves) and the resulting damage;
- Budgets and expenditures on health services, disaster prevention and damage repair (recovery).

These data would allow the international community to better assess the causes and impacts of, and the responses to, climate change at the global, regional and

Figure 14.1: GDP and CO_2 Emissions



Linking population with economy and GHG emissions:

What is the relation between GDP and CO_2 emissions?

Will it remain the same in the future?

Data source: GEO Data Portal http://geodata.grid.unep.ch

national levels. Nevertheless, because of the costs and efforts required to acquire and update these data, their relevance must be clearly defined. From an empirical point of view, the spatial and temporal completeness of existing data must be assessed, since many sociodemographic indicators are still incomplete. For instance, figures on education, poverty and governance are only available for a limited number of countries, and past data, as well as projections, are difficult to obtain. The redundancy of data also needs to be evaluated. For instance, it is well known that GDP and the Human Development Index are highly correlated. Therefore, the simple use of the more complete GDP data could be enough (and more efficient) as a proxy for the study of development levels. Some data are easily accessible because of well-established and standardized observation processes (economic accounts, environmental measurement networks, national statistics), whereas others are more difficult to acquire because they come from irregular surveys and subjective perceptions (e.g., the governance indicators). In parallel to these pragmatic considerations, and more fundamentally, data must fit into a properly defined theoretical model in order to be fully relevant as indicators for climate-change studies, as will be discussed in the next sections.

Framing data and indicators

Definitional problems

Is GDP a mitigation or adaptation indicator?

It is not always clear how to categorize data into mitigation, impact or adaptation indicators nor is it clear how to draw the line between these three groups. For instance, GDP is listed above as a mitigation variable, but it is neither directly nor linearly linked to greenhouse gas (GHG) emissions, in particular to CO_2 emissions (see Figure 14.1). This relationship is influenced by other factors such as the technology available, the structure of the economy, the level of imports/exports and the nature of consumption by households, among others. Furthermore, decoupling economic growth and environmental pressure is an explicit objective of some environmental policies (e.g., the Environmental Strategy of the Organisation for Economic Co-operation and Development [OECD]). The fact that GDP is not the only relevant driver of GHG emissions is nothing new, but GDP is still considered a main, or at least indirect, driving factor in many climate-change assessments.

On the other hand, GDP can be used to assess the impacts of climate change on the economy: Weather-related disasters can destroy livelihoods and infrastructure, affect the working population through diseases, thus diminishing the production capacities of a territory. Finally, GDP can be seen as a vulnerability proxy since weaker economies might have more difficulties in adapting to climate change and to its related effects. Large and diversified economies have more power to absorb the shocks of disasters than small and single-sector-based economies.

What is population?

The same questions apply to population as a driver of GHG emissions. The number of people as such might not be the main determinant of consumption and emission levels. The structure of households (size, age and composition) and their consumption habits may have a strong role (O'Neill et al., 2002). Therefore, additional demographic variables (along with their projections for the next decades) may be needed, at various spatial scales, to properly estimate future emissions patterns.

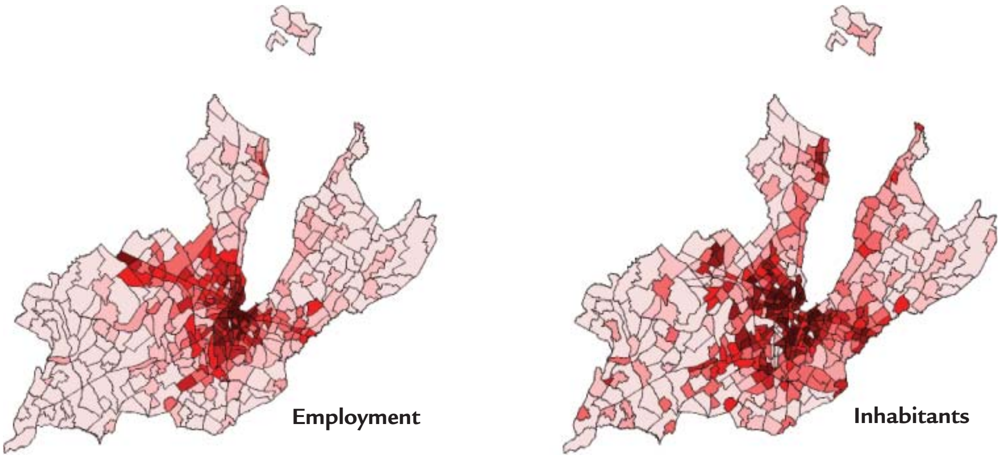
Population is impacted by climate change, and it will act to adapt. In assessing potential impacts, the traditional residential approach to inventorying population may not always be the most relevant one. In the course of a normal week or day, people are often not at home. They work, travel, shop and engage in leisure activities in many different places. Population maps based on census data show a specific spatial distribution that is representative of certain time periods and population groups (e.g., non-active versus active). For risk management, it also necessary to complement this view with other data such as those on working and shopping locations, which are more appropriate for locating people during the daytime. Figure 14.2 shows the difference between employment and residential locations in Geneva in 2000.

In terms of adaptation, additional data on the structure of the population might be useful. Median age, age dependency ratio and life expectancy are important indicators of vulnerability as well as of the capacity of a territory to react to future shocks. Ageing, for example, is occurring in industrialized countries, but it might be counterbalanced by an expected higher life expectancy in the next decades (Johansson et al., 2002).

Multi-dimensional approaches

The preceding remarks underline the importance of placing each indicator into context, if not into a structured model. Since the 1970s, studies on the relation-

Figure 14.2: Population, Geneva, 2000, from Employment and Residential Data



ships between people and the environment have progressively made use of more and more sophisticated models for understanding the nuances of these linkages, e.g., in the fields of land-cover/land-use change or climate change (de Sherbinin et al., 2007). The development of population-environment theories was also made possible by the increased availability of data at different temporal and spatial scales. These models combine, in an integrated way, knowledge on both the bio-physical and the socio-economical dimensions of the earth system from multiple disciplines. Based on quantitative and qualitative data, the models are subject to various levels of uncertainties which have to be expressed. They are abstract and simplified views on the states and processes of the real world, which can (and should) support information and decision-making.

One famous example of a simple model is the "I = PAT identity" (impact [I] = population [P] x affluence [A] x technology [T]), introduced in the early 1970s. The I = PAT equation was applied in the field of climate change, in particular in the IPCC Special Report on Emissions Scenarios (SRES) (IPCC, 2000), for expressing emissions (e.g., CO_2 emissions) as a function of population, income and energy intensity:

$$CO_2 \text{ Emissions} = \text{Population} \times (\text{GDP}/\text{Population}) \times (\text{Energy}/\text{GDP}) \times (CO_2/\text{Energy})$$

More complex examples include global scenario studies, such as the IPCC SRES, the United Nations Millennium Ecosystem Assessment or the *Global Environmental Outlook* (GEO), the 'flagship' report of UNEP. Since its first edition in 1997, the GEO has developed an increasingly integrated approach to environmental analysis, making use of indicators and reporting. This has resulted in a whole range of global, regional, national, local and thematic reports as well as various databases, information and learning tools and other resources. This type of environmental assessment is a key vehicle for promoting the interaction between science processes and the various stages of the policy- and decision-making cycle. These studies underpin decision-making by UNEP's Governing Council, the various Multilateral Environmental Agreements, regional ministerial environmental forums, the private sector and national and local authorities.

The methodology of the GEO Integrated Environmental Assessment (IEA) report series is now well established and documented.[2] It follows a multi-thematic, multi-region and scenario-based approach. It is adapted and applied to various spatial scales, from the global to the regional, national and local/urban (e.g., GEO-Cities reports). This series of studies is based on the model, "Driving Forces – Pressures – States – Impacts – Responses" (DPSIR), a framework for analysing the interactions between society and the environment. DPSIR, an extension of the previous OECD pressure-state-response (PSR) model, enables a formal and causal analysis of factors that have an influence on the environment. Although sometimes seen as too mechanistic, the DPSIR framework helps to structure data and indicators on various dimensions of environmental problems. These data are the foundation of subsequent analyses. Networks of partner institutions around the world (namely, the GEO collaborating centres) have provided data and interpretations at various levels of analysis. These have been disseminated through global and regional GEO Data Portals,[3] which have found users far beyond the GEO partners.

Policymakers often face a growing list of environmental challenges. Many of these are complex: They have a direct or indirect effect on human well-being and require an enhanced understanding to support effective response measures and actions. Integrated environmental assessment and early warning approaches have strengthened the harmonization and the accessibility of reliable environmental data and information for improved policymaking at different levels. Data portals have considerably facilitated the practical use of data by means of graphs, tables or maps or by providing for the downloading of data sets in GIS compatible formats.

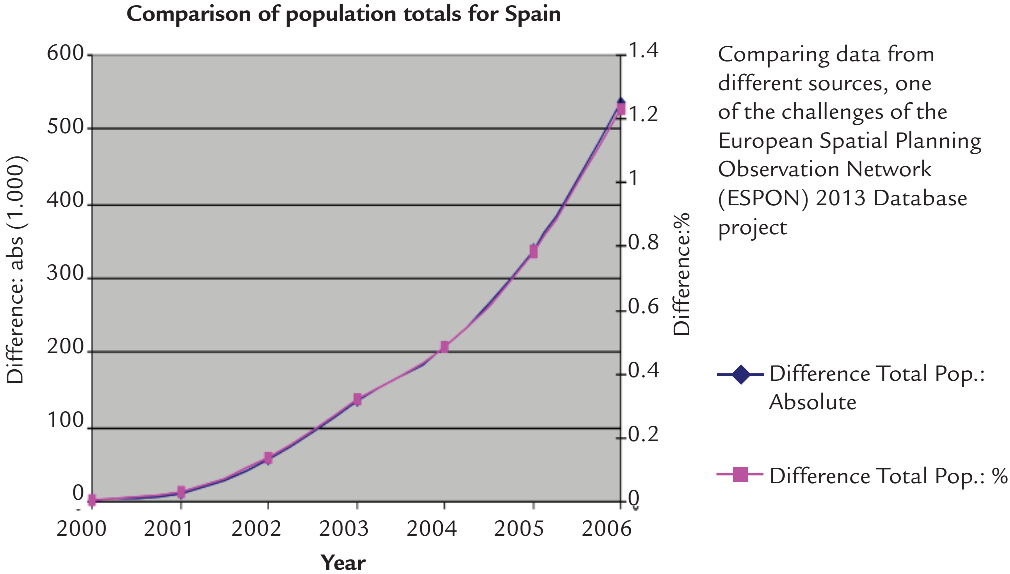
Today, there is a greater investment by the international community and governments in environmental assessments and early warning information services, in terms of both human and financial resources. However, despite the availability of considerable information on the state and trends of the global environment, there is a lack of adequate and relevant data, and there is a lessened capacity of monitoring and data collection systems, especially when detailed, up-to-date and complete data are needed at various scales.

Data needs for different scales of analysis

While a vast amount of data and indicators is already available for analysis and information purposes, more data of high quality are needed. National statistical offices can play an important role in collecting new and additional data and—together with the United Nations and other agencies—in strengthening and harmonizing existing surveys and other data collection activities in the area of adaptation to and mitigation of climate change.

In order to be scientifically credible and policy relevant at the same time—which do not always go together—it is of critical importance to work with sound,

Figure 14.3: Population Data Discrepancies between European and United Nations Data, Spain, 2000-2006



reviewed data, preferably from official records. National statistical offices and international agencies play an equally important role in collecting and harmonizing census data. Additional research and modelling are needed to assist with data harmonization, analyses of interlinkages and the development of scenarios.

Besides 'real' physical climate data, it is important to consolidate and improve authoritative data collections and compilations in the socio-economic and natural resources realms, using statistical surveys, as well as other sources such as satellite imagery—the end goal being to have proper, authoritative data in place to assess and address climate change issues adequately at all levels.

In terms of population, the two key variables, of course, are size and distribution—both to estimate absolute figures and to derive per capita data. As already stated, changes in distribution and size are as important, i.e., data on mortality, fertility, age composition, urbanization and migration. In addition to historical data (trends), projections and scenarios are needed to show the potential impacts and effects of environmental and other policies.

For both analysis and policy formulation activities, scale matters: "[A]s different phenomena take place at different spatial scales, the preferred spatial scale depends on the analysis undertaken" (van Vuuren et al., 2007, p. 114). Data for large regions or groups of countries are sufficient for global assessments and scenarios such as those developed in the GEO or the SRES studies. Global models, however, hide variations between and within countries (for instance, energy intensity may vary considerably from one country to another). Thus, national data are required for international negotiations or for the implementation of environmental conventions. For local activities linked to vulnerability and adaptation to climate change, such as land-planning or sanitation, detailed and geo-referenced data are needed because of the spatial variation of determinant factors such as land cover/land use, terrain, location of infrastructures and access to water, among others.

The following section addresses some of the aspects related to the comparability of information sources as well as to the spatial disaggregation of demographic data.

Comparing population data sources

Climate change modelling or environmental assessments often face the problem of data scarcity. It is also possible that more than one data source is available. This is the case for CO_2 emissions at the global level (UNFCCC and Carbon Dioxide Information Analysis Center [CDIAC] country data, for instance, can be found on the GEO Data Portal) or for population data when international data sources are compared to regional data. In this view, the European Spatial Planning Observation Network (ESPON) 2013 Database project[4] is currently conducting a compatibility study in order to evaluate the compatibility among data from the United Nations community (UN Statistical Division, UNEP) and those from the European Union (Eurostat, ESPON).

Preliminary results indicate that some countries show large discrepancies among data sources, as seen in the example of Spain where differences increase through the time-period 2000-2006 (see Figure 14.3).

In general, observed differences are higher when indicators are further disaggregated: In the example provided for data on age-classes in Belgium in 2005 (Figure 14.4), a maximum difference of 3.4 per cent is reached by the age-class 85+ against only 0.1 per cent for the total population (i.e., the sum of all age-classes). In some cases, the discrepancies can be easily explained by differences in the definition of territorial units (e.g., the inclusion of overseas territories in the definition of France), but this is sometimes less clear for other cases.

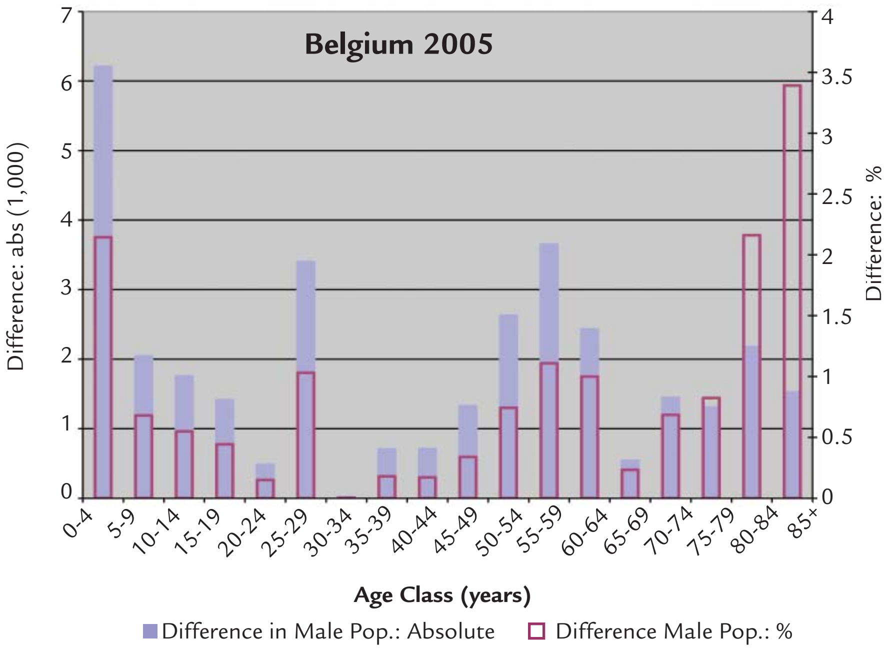
The same observations can be made for demographic projections. In the case of total population projections to 2050 for Europe, the main United Nations variants from *World Population Prospects: The 2006 Revision* (United Nations, 2007) and the models from the ESPON project 1.1.4, "The Spatial Effects of Demographic Trends and Migration" (Johansson and Rauhut, 2002), depict a wide range of scenarios (see Figure 14.5).

All scenarios are modelled using basic demographic variables such as fertility and mortality rates and migration. The inclusion (or exclusion) of these variables, along with assumptions about their evolution, explain the differences between the scenarios.[5]

Downscaling Population Data and Scenarios

Once data sources are identified and clearly understood in terms of what they measure, there may be a need to refine the available (generally measured) data by means of estimation models, in order to achieve higher spatial resolution. This process, known as spatial disaggregation, has been conceptualized and applied

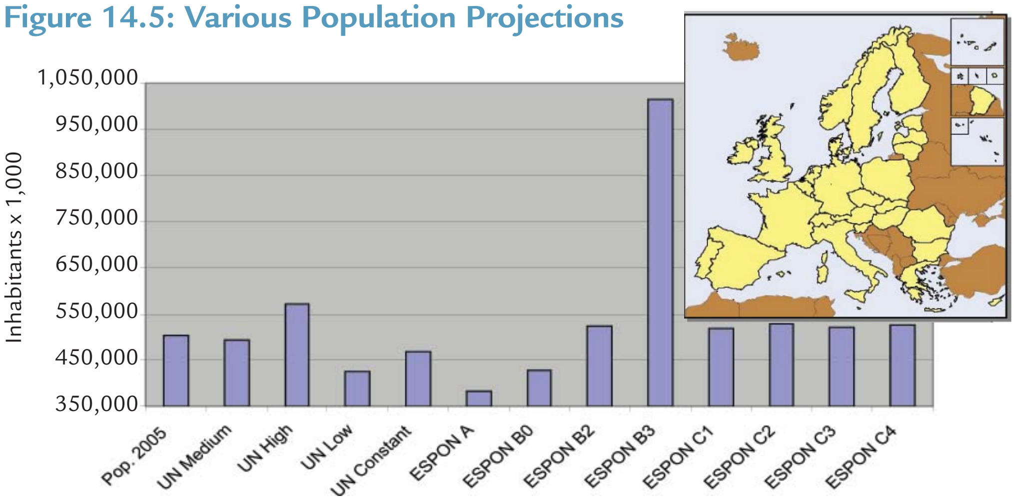
Figure 14.4: Age-class Data Discrepancies between European and United Nations Data, Belgium, 2005



in different fields including biodiversity mapping (estimation of species distribution), climate modelling and poverty and population mapping. A wide range of statistical, physical and deterministic models (or a combination of these) has been developed. The next sections focus on demographic data disaggregation models.

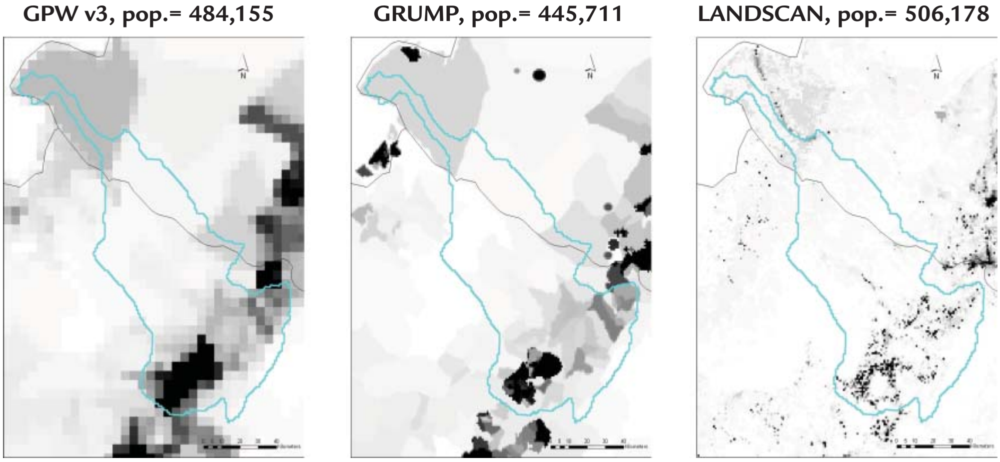
Downscaling demographic data: Population data are generally available by politico-administrative areal units (countries or sub-national units). The most complete data come from censuses. Administrative registers (population, electoral

Figure 14.5: Various Population Projections



Note: Scenarii for EU27 + CH & NO (scenarii variables: fertility, mortality, migration)

Figure 14.6: Population Exposure to a Flood, from GPW, GRUMP and LandScan Calculations



Example of population figures extracted from three data sources for a single flood event (in light blue)

lists, vehicle registrations, tax records) can provide reliable data in some countries. These data can also be complemented by surveys, which cover only a sample of the phenomenon to be observed.

The politico-administrative type of spatial units is relevant for decision-making purposes since they represent the spatial extents of political power. However, they are not well suited to environmental studies because ecological phenomena have different boundaries, if they have boundaries at all (e.g., temperature, altitude).

Since integrated models and assessments imply the combination of various dimensions of the environment, a common spatial reference is needed, the simplest one being a regular grid of square cells (a raster grid). To illustrate how data by areal units can be transformed into gridded data, four examples are briefly described in Figure 14.6.

The Gridded Population of the World (GPW v3)[6] is a global population data set at the resolution of 2.5 arc-minutes (5 km at the equator) for every five-year interval from 1990 to 2015. Data on more than 400,000 politico-administrative units (with figures from the two most recent censuses circa 1990 and 2000) have been extrapolated to the selected years and rasterized using a simple assumption of uniform distribution of population. The main effort has been in the acquisition of the most detailed source data possible. An extension of this product is the model developed by the Global Rural-Urban Mapping Project (GRUMP), which makes use of ancillary data such as satellite imagery for further distributing population between urban and rural areas at a spatial resolution of 30 arc-seconds (1 km at the equator).

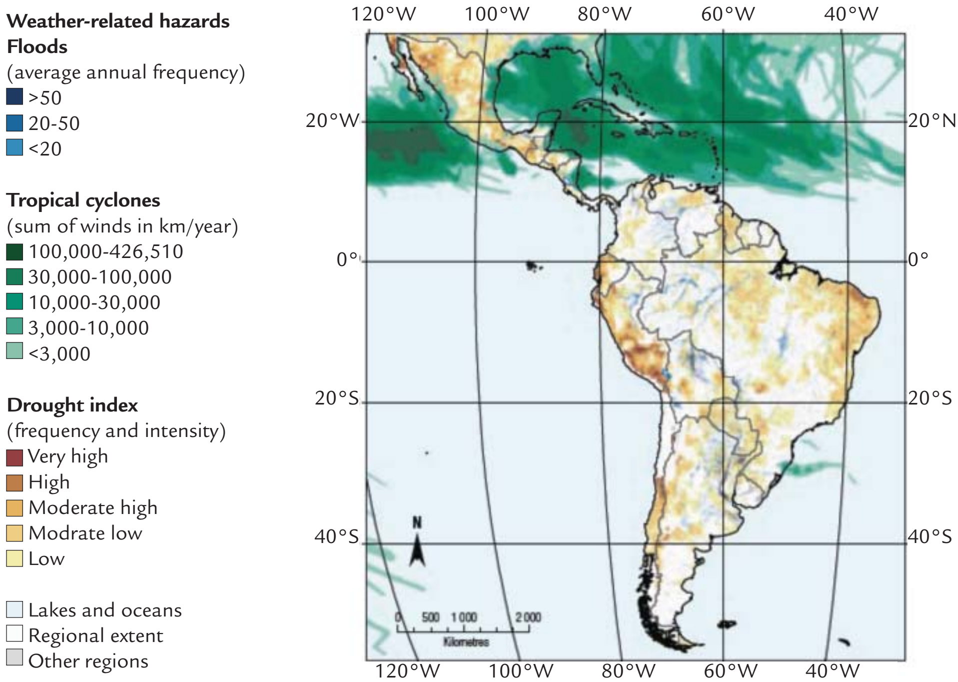
Another data set, LandScan,[7] provides a global raster grid at a 30 arc-second resolution. The assumptions for the distribution of population aim at representing the so-called ambient population, which integrates movements and travel. Night-time lights imagery, data on elevation, land cover and transportation networks are used to estimate population in each cell of the grid. The objective of LandScan is not to count people at their place of residence, but rather to provide an estimate of their "likely ambient locations integrated over a 24-hour period for typical days, weeks, and seasons".[8] The concept of ambient population differs from the residential approach of GPW. Only the most recent versions of LandScan (2006 and 2007) are available because the methodology has changed since the original 1998 modelling.

A third type of model developed at UNEP[9] also distributes population in a non-uniform way, on the basis of an accessibility index calculated by means of data on transportation and settlements. The model assumes that population tends to locate in the most accessible areas.

Starting from more or less the same demographic data by sub-national units, these models result in different pictures of population distribution. Although each model has its rationale and validity, the use of one or another has different implications. In Figure 14.6, for example, a flood event is drawn based on GPW, GRUMP and LandScan data. The calculations of the population affected by this event show contrasting figures, depending on the data source considered.

In any case, the assumptions behind the models should be known and documented. General evaluation criteria for selecting a downscaling model can nevertheless be proposed: "(1) consistency with existing local data (for the base year); (2) consistency with the original source (the scenario data on the much coarser scale); (3) transparency; and (4) plausibility of the outcome" (van Vuuren et al., 2007, p. 115). These criteria are partially met by the GPW/GRUMP and LandScan data sets. Local data have been used in the GPW/GRUMP grids since they are derived from almost 400,000 base administrative units, against 70,000 for LandScan 2000 (although several thousand units have been added in subsequent versions of LandScan). The consistency with original data is met by both data sources, since the GPW/GRUMP and LandScan methods simply distribute population within each original spatial unit. Furthermore, GPW provides additional extrapolated population grids that are explicitly adjusted to United Nations' national scenarios until 2015. The transparency is very high for the GPW/GRUMP products: Methods and data sources have been documented and published. For LandScan, a basic documentation is available, but demographic data sources are not clearly described, and the details of the method were not published. LandScan, however, has evolved in such a way that comparisons between the various updates are impossible. Finally, the plausibility of the modelled population values depends on the objective of the users. The GPW grid is based on the assumption of a uniform distribution of population within each spatial unit, which is in fact very unrealistic. But this is counterbalanced by the effort put into collecting the most possibly detailed base demographic data. GRUMP, while improving the GPW spatial resolution by a factor of five, is also introducing a more precise distribution of population between urban and rural areas. Both GRUMP and GPW provide an indication of the residential population. LandScan, on the other hand, assesses a very different concept of ambient population, i.e., the potential presence of population through

Figure 14.7: Compilation of Hazard Data, South and Central America



Source: ISDR, 2009.

time at a given place for various reasons (residence, travel, work, leisure, etc.). This idea might be relevant, for instance, for risk management purposes.

Downscaling scenarios: Similar to downscaling actual data, demographic projections and scenarios have been spatially disaggregated in recent global assessments. For instance, various models for downscaling the IPCC's Special Report on Emissions Scenarios (SRES) scenarios to the grid level (0.5° x 0.5°) have been developed (Gaffin et al., 2004; Grübler et al., 2007; van Vuuren et al., 2007). These models downscaled drivers of climate change: emissions, population and GDP. In the most recent of the examples cited (van Vuuren et al., 2007), 17 world regions of the SRES scenarios were downscaled to the national and grid-size levels (0.5° resolution, i.e., 55 km at the equator). In order to achieve the grid estimation of population, national growth rates for each of the SRES scenarios have been linearly applied to each grid cell of the GPW 2000 data which is used as the base grid. The gridded GDPs were obtained by multiplying the national GDP per capita by the population grids. GHG emissions were only disaggregated at the national level by means of the I = PAT model.

For further sub-regional or national studies, finer downscaling might be needed in order to reach decision-making relevance at these scales. In particular, emissions should be disaggregated at the grid level, and more data on land-cover/land-use change incorporated. This is, for instance, the aim of the recently launched

European Union's Seventh Framework Progamme's (EU/FP7) Envirogrids[10] research project, which will evaluate the impacts of climate change on the quality and uses of water in the Black Sea Basin (covering 2,000,000 km^2, 24 countries, 160,000,000 inhabitants.). Climatic and demographic scenarios will be downscaled to 25 km and 1 km resolutions, respectively. Land-cover data already available at medium resolutions (250 m to 1k m) will be projected up to 2030. The main challenge in this modelling process is to keep the models as independent as possible (e.g., not to use population scenarios for forecasting land-cover changes) in order to allow comparisons between the resulting figures.

Data Needs for Long-term Analysis of Impacts, Vulnerability and Adaptation

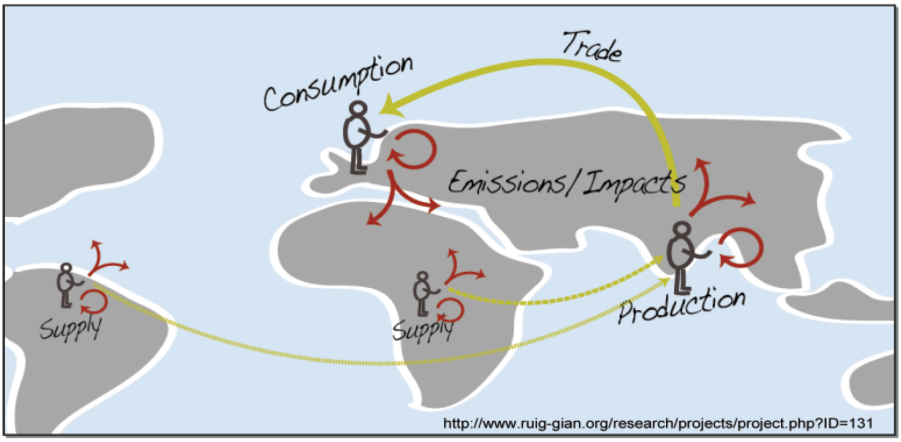
Long-term early warning

Previous sections have introduced the complexity of designing and acquiring appropriate data from the thematic and spatial points of view. The time dimension is also essential when considering the inherent uncertainties of scenarios and projections, but also important for establishing mitigation and adaptation policies. Many people seem to agree that the hard distinction between short-term disaster response and recovery and longer-term planning is not necessarily beneficial for policymaking.

Most people think of early warning in terms of immediate and short-term concerns such as major weather events (hurricanes, cyclones, tornadoes and the like), climatic variation (El Niño events or droughts caused by lack of rainfall) or geo-physical events such as earthquakes and tidal waves. These immediate and often unpredictable events require specific measuring, information and advisory systems, as implemented or coordinated by specific national and international organizations. These activities are essential for efficient response and recovery actions, but the focus of organizations such as UNEP is also on identifying issues which take much longer to develop and might better be identified as 'emerging environmental threats'. These may take the form of environmental degradation that increases the vulnerability of ecosystems (including humans, often in combination with socio-economic stresses); cumulative environmental threats where the accumulation of pollutants collectively increases the vulnerability of ecosystems; environmental threats that have not been perceived as such in the past, but that new evidence indicates might be deleterious to ecosystems; or more speculative, long-term issues where scientific evidence may be inadequate at present but discussions and assessments have identified as a possible environmental problem. Depending on the relative socio-economic vulnerability of a given community, these environmental threats can (drastically) alter ecosystem functioning and have a major impact on human security and the biodiversity of the planet. The recognition that environment is a key ingredient of development has made the ability to provide early warning on longer-term and cumulative environmental threats much more important.

Figure 14.8: Tracking Consumption, Production and Health Impacts

Pollutant emissions and impacts do not occur only at place of consumption



Source: Tracking Environmental Impacts of Consumption (TREI-C), a research project @ GRID-Europe.

Global assessment of environmental risks

Such long-term linkages between environment and development is central to the recently published Global Assessment Report (GAR) (ISDR 2009), a global study of intensive and extensive disaster risk in the context of development and climate change. It is a very good example of an integrated approach to a subject (disaster risk) that cannot be analysed in one unique dimension. This report links the observed or potential losses to the exposure and vulnerability of population and assets towards natural hazards. The conceptual framework of global risk modelling is a simple equation proposed by the United Nations Disaster Relief Organization (UNDRO, 1979):

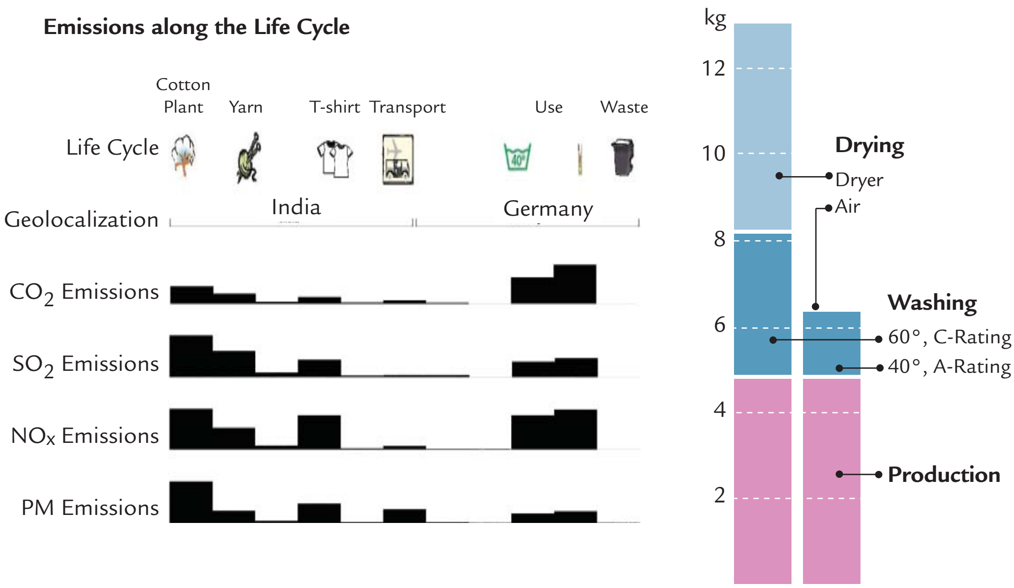
Risk (losses) = hazard x exposition x vulnerability

The most possibly detailed data on losses (human and economic, from the EM-DAT[11] and DesInventar[12] databases) and hazards (including cyclones, droughts, floods, earthquakes, tsunamis, landslides) have been compiled (see Figure 14.7).

The hazard maps have been overlaid on the gridded population (LandScan) and GDP data in order to calculate human and economic exposures to each of these risks. Finally, a statistical analysis of vulnerability indicators (mainly available at the national level) enabled the identification of the main risk factors, such as poverty, poor governance, urban population growth, isolation of rural areas and ecosystem decline. All these factors need to be addressed in the long term.

One other striking conclusion of the report is that risk and exposure are highly concentrated and increasing. Despite the successes attained in vulnerability reduction (through development), risk is still rising because of the growing exposure of people and their assets.

Figure 14.9: Emissions during the Life-cycle of a T-shirt



Effects of climate change were also related to the observed increase in intensity of hydro-meteorological hazards such as cyclones. But the evaluation of the impacts of climate change on hazards is only at an early stage and requires further investigation. This is particularly important because more than two thirds of the mortality and economic losses from reported disasters (1975-2008) are associated with hydro-meteorological hazards. Although a large amount of risk, hazard and vulnerability data compiled for the GAR report is already made freely available on the internet,[13] it is expected that more data will be collected on the various dimensions of risk since "there is a growing international commitment to addressing disaster risk, poverty and climate change" (ISDR, 2009, p. 14).

Closing the circle: linking consumers, producers and the impacted population

Risk analysis also shows that drivers of climate change in one place (e.g., emissions in industrialized countries) may have impacts in other places (e.g., in poor and vulnerable countries). In addition, situations today can lead to future vulnerabilities. Environmental assessments have to take into account remote distances and futures, which, in fact, is in line with the principles of sustainable development. Examples of such approaches can be found in the novel ways environmental and economic accounting are being carried out. It is now recognized that classical national (e.g., Kyoto protocol emissions accounts) or residence-based accounting (e.g., GDP) must be complemented by other allocation schemes in order to properly evaluate the impacts of the consumption of goods and services throughout the world. Life-cycle analyses—as well as multi-directional/multi-sectoral trade flow data (such as the GTAP databases[14])—permit the reallocation of emissions among consumers and producers. Such models have so far mainly been applied to regional analyses of global pollutants such as CO_2. They have shown large discrepancies in the carbon intensities of production between producing and consuming regions.

The recent TREI-C study[15] has included emissions of additional pollutants such as fine particles or heavy metals and assessed their health impacts in terms of disability-adjusted life years (DALYs). Such a model thus integrates life-cycle analysis, macroeconomic data on trade and production, pollutant transfer models (through air and water) and epidemiological studies about the effects of pollutants on health.

The integration of such diverse models is required for tracking the complete chain of causality from consumption to final impacts through time, space and actors (see Figure 14.8).

The life-cycle analysis provides crucial information about where and when most pollutant emissions occur during the lifetime of any given item. In the case of a T-shirt, which was carefully examined in the TREI-C study, it was demonstrated that the use phase can double CO_2 emissions due to the frequent use of washing machines and electric dryers (see Figure 14.9).

For such easy-to-track examples, mitigation measures appear immediately: Consumers have to wash less and/or producers must design clothes that do not smell! Unfortunately, other types of goods such as electronic appliances are made of a complex mix of components produced in many parts of the world. The life-cycle analysis of such products would require more data which may be available in the future, as the interest in such new types of accounting will grow in the context of international environmental negotiations.

Conclusions

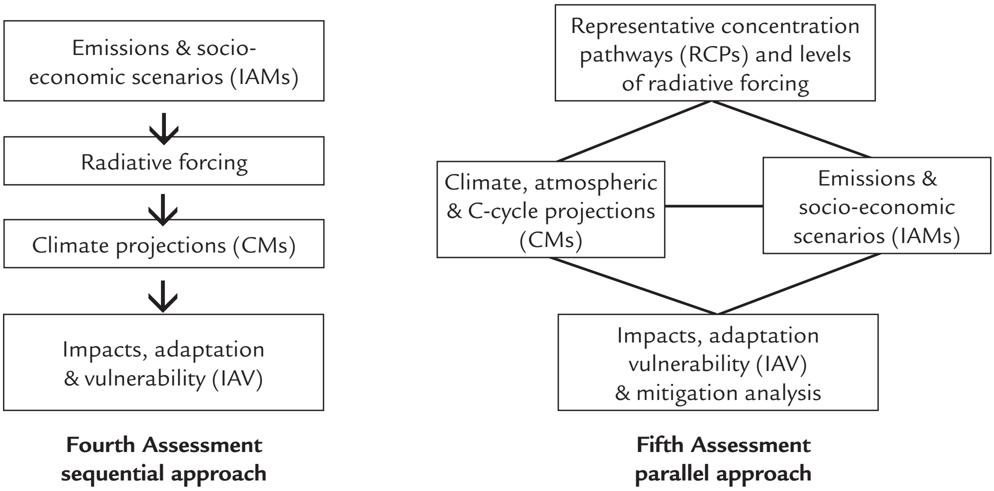
The following general conclusions can be drawn from the examples of data analysis and applications that have been presented in this chapter, as well as from the need for more attention to population issues related to the environment and climate change:

1. **The role of population data for climate change analysis can be strengthened and linked to the reorganization within the IPCC and the lack of coverage of population issues in the current debate.**

Population dynamics are at the centre of the climate change issue, yet they receive little attention. The general debate focuses more on the economic and technological aspects. However, there is undoubtedly a strong interest by the international and scientific communities in better integrating population in the analysis and properly assessing the population-related causes and impacts of climate change. More and better population data in terms of contents, scale, quality and time coverage are needed in order to undertake more relevant and rigorous scientific assessments that can have a significant influence on the political and societal debates.

With the reorganization of the analysis and assessment activities for the IPCC Fifth Assessment, population and socio-economic scenarios are no longer at the

Figure 14.10: Approaches for the Development of IPCC Global Scenarios



Source: Modified from Moss et al. 2008.

base of all subsequent sequential analyses (see Figure 14.10), as was the case in the IPCC Fourth Assessment. With the newly adopted parallel approach (Moss et al., 2008), population and socio-economic scenarios are now directly linked to the three other components, and therefore the need for improved population data is even greater.

2. There is a need for broader consultation and discussion around the needs for data collection and analysis.

Generally speaking, there is a clear need for better identification and expression of data needs for addressing climate change and population dynamics. Due to the complexity and interlinkages of these issues, conceptual and formal models must be further developed, taking into account the availability of data.

The methods for data creation and estimation must be made more explicit, and they must be made more understandable to a wider audience. In particular, the distinction between observed and modelled data must be clarified, in order to address issues of uncertainties attached to some data, such as projections. The IPCC Fourth Assessment Report (AR4) provides a good example of how to present synthesized methodologies and evaluation of uncertainties.

In order to support such global assessments with relevant socio-economic data (including data on adaptation and mitigation), improved international cooperation is necessary. Data is costly to acquire and maintain; priorities must be set; redundancy and overlap in the collection and dissemination of data must be avoided where possible.

Nevertheless, variety and discrepancies in data sources, in particular between international and local scales, will always be observed. Acknowledging and explaining these differences is necessary, i.e., identifying the reasons for such variability, whether this is linked to definitions of the observation or measurement units or to measurement techniques. Coordination will not necessarily or always lead to the consensus and efficiency, for example, of appropriate and unique data sources in each thematic domain (demography, vulnerability, adaptation, etc.). Similar data may seem redundant but still have their own rationales for existence. For instance, data sets on transportation networks are sometimes acquired and analysed several times by many different actors in the same territory (public administrations, private companies, specific projects, etc.) due to specific information needs, different levels of application or various copyright issues.

In this respect, participation in evaluation processes and trust-building between stakeholders in climate-change assessment activities is important in order to validate the data provided.

3. Quantitative data analysis needs to be integrated with evaluations of governance and other qualitative assessments.

When attempting to integrate heterogeneous actors and ways of measuring reality, it is necessary to compare and evaluate numeric data and formal models with other types of more qualitative knowledge, including expert opinion, common sense and indigenous information. There are conceptual and practical reasons to consider subjective evaluations (e.g., governance indicators, perception of risk by local actors). Many agencies have relevant data to bring to the debate, and it can certainly be more efficient to integrate them early in the assessment process, rather than to be confronted with opposition and rejection once the figures are published.

4. There are excellent opportunities for strengthening the role of the United Nations in moving the population-climate agenda forward.

In the broader participatory and catalysing aspects of data management, the United Nations can play an instrumental role by fostering and coordinating data collections at global, regional and national levels, as well as by improving the coherence, quality and accessibility of population data for a greater knowledge of the complex problems at stake. All this, with the ultimate goals of improving the science base for sound decision-making and taking sustainable actions.

Notes

1 According to IPCC (2007), in 2000, UNFCCC Annex I countries (industrialized countries) had 0.683 of kg $C0_2$-equivalent emissions per US$ of GDP_{PPP} against 1.055 for developing countries.

2 See: UNEP, 2007.

3 See: UNEP, n.d., Geodatas.

4 See website: www.espon.eu/, last accessed 2 October 2009.

5 The ESPON scenarios A (no immigration) and B3 (with high immigration for a constant age-dependency ratio) are unrealistic but illustrate the problems of immigration and financing retirement systems.

6 See: SEDAC/CIESIN, n.d.

7 See: Landscan, n.d.

8 See the documentation on the LandScan website: www.ornl.gov/sci/landscan/, last accessed 7 October 2009.

9 See website: http://na.unep.net/globalpop/africa/, last accessed 8 October 2009.

10 See website: www.envirogrids.net/, last accessed 2 October 2009.

11 See Emergency Events Database website: www.emdat.be/, last accessed 3 October 2009.

12 See website of: Corporacíon OSSO, Valle, Colombia: www.desinventar.org/, last accessed 1 October 2009.

13 See: UNEP, n.d., Preview.

14 See: Purdue University, n.d.

15 See: International Academies Network, n.d.

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