

The World Bank Group

## 2010 Environment Strategy

Analytical Background Papers

### **Monitoring Environmental Sustainability** *Trends, Challenges and the Way Forward*

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## **Executive summary**

This report presents a concise review of the major environmental and natural resources issues at the global and national level over the coming two decades. The environmental issues reviewed include air pollution and deterioration of air quality, greenhouse gas emissions and climate change, water quality, scarcity and access, land and soil degradation, deforestation and forest degradation, natural disaster, loss of biodiversity and protected areas, and governance and institutions for environmental and natural resource management.

Besides providing an environment outlook, the report tackles the issue of monitoring also from the supply side. It identifies the relevant data and indicator sets available at the global level and country level to capture the global and locally relevant environmental issues with the underlying objective of pinpointing at data gaps. It concludes with a set of recommendations for moving forward on the monitoring agenda.

### **Status and trends of environmental challenges**

The analysis of drivers of environmental change and their impacts on nature, people and the economy sheds light on the challenges the world faces over the coming two decades. Most trends in this report are projected to 2030.

Environmental challenges are increasing. Emissions from transport and energy supply will contribute heavily to GHG emissions growth up to 2030. Also deforestation in the tropics, while overall on a slightly declining rate, and expanding agricultural activity will continue driving a major portion of GHG emissions. Black carbon as well as particulate matter emissions from anthropogenic fuel combustion will cause deteriorations in urban air quality. Areas severely affected from water stress will increase dramatically and insufficient sewerage systems will contribute to the shortage of clean water. Land cultivation area will grow by ten percent between 2005 and 2030 due to agricultural activities. This expansion in cultivated area means that worldwide soil erosion risk will double by 2030. Declining biodiversity and ocean acidification are further causes of concern. Extensive resource extraction will continue to increase under the pressure of increasing production. Additional pressing challenges will be the spread of ground level ozone and municipal waste generation from increasing material use. Declining GHG emissions per unit of GDP and increasing protected ecosystem areas show signs of improving governance and management.

Overall, the threats from climate change caused by GHG emissions, biodiversity loss, water pollution and scarcity as well as pressure on land as well as worsening ocean's state and biodiversity have to be taken under close observation in the period over the next 20 years. Development policy, while working towards the goal of poverty alleviation, should take into account these environmental and natural resource issues in order to maximize development outcomes and avoid possibly irreversible impacts on future generations and the poorest sectors of today's society.

## **Information and data challenges**

The environment challenges that the world faces are not trivial and some of them require immediate action. Action, in turn, requires reliable and accurate information. The second part of the report looks at information from the supply side. It identifies the relevant data and indicator sets available at the global level and country level to capture the global and locally relevant environmental issues with the underlying objective of informing and advising decision making and to identify the data gaps.

How well prepared is the development community to monitor progress in reducing environmental and natural resource degradation? This question is tackled in the paper by reviewing data and indicator sets available at the global level. The main areas of concern include:

- Indoor air pollution: Initiatives at the local level, particularly to measure dose-response functions and impacts, as well as sex- and age-differentiated impacts, are virtually non-existent.
- Urban air pollution: The analysis showed that there is limited data on air quality and its impacts at the sub-national level. Extrapolation to the country level is often based on models, and country level results vary in quality depending on the availability of monitoring sites in the country. Data on pollution should be complemented by indicators which are attributable to specific pollution exposures.
- Water quality: There is limited comparable data on water quality at the regional/sub-national levels. Proxy indicators such as incidence of diarrheal disease are however available.
- Land and soil degradation: Initiatives to monitor land degradation are often unsatisfactory and limited in time.
- Forests: The review showed that there is limited data on the degradation of forests.
- Biodiversity: There are not databases which record the overall health of ecosystems or that assess the value different ecosystems have for men's and women's well-being and for production.

## **Moving forward on monitoring**

The last section of the paper looks at four areas of engagement that could prove crucial in the way environmental monitoring is performed and used.

ICTs are playing a key and rising role in environmental management and monitoring. The International Telecommunication Union (ITU, 2008) has identified six main applications of ICTs in the area of environment: observation, analysis, planning, management and protection, mitigation and capacity building. The developing countries face a number of challenges in using

ICTs for environmental monitoring and sustainability. They have problems with limited infrastructure, low institutional capacity, low capacity to integrate scientific data into decision and policy making, and limited capacity to implement policy recommendations. There are a number of crucial issues to address for making progress. One issue involves scaling up the use of new web-based technologies such as Web 2.0 and service-oriented architecture, which allow more ready access to global data sets. Second, it is important to adopt open standards to ensure interoperability; the data which has been organized and stored in servers around the world should be linkable, via the Internet, and also usable without having to address software, coding and other format incompatibilities or restrictions which would limit the use of this data. Third, it is critical to invest in high speed access to the Internet which will help countries to get access and contribute information as well. Fourth, it will be helpful to make use of battery-operated data collection devices which can transmit information using either wireless or satellite transmissions.

The private sector is a stakeholder in the environment and therefore has a role to play in environmental monitoring. While more businesses realize cost-saving or profit-making opportunities in reducing emissions and adopting greener business models, it is yet to be established if the private sector has strong enough incentives for using standards for environmental monitoring. The International Finance Corporation (IFC) is a leading actor in setting environmental standards for its clientele, and other financial institutions adopt and apply them as part of the Equator Principles<sup>1</sup>. IFC has joined forces with the Global Reporting Initiative to encourage the private sector to report on their environmental, social and governance performance. They have identified overlapping areas in their frameworks and indicators. IFC can push the envelope by using ICTs for collecting the information from the clients, share the information internally and externally, and push the environmental agenda from the perspective of the private sector further beyond sustainability of their operations.

Comprehensive frameworks for environmental accounting, and in particular wealth accounting, are rapidly being used by national government agencies, international organizations, and by the UN bodies. In recent years, a number of developing countries, such as Brazil, China, India and Mexico, have developed environmental accounting programs. The assets which are covered by the accounting include sub-soil resources, timber and land. The assets which have been featured most prominently and most regularly are non-renewable ones such as oil, natural gas, coal and minerals. Key actions for the short- and medium-term include: (i) collecting information on the costs of extraction of non-renewable resources; and (ii) building capacity and investing in estimates of the benefits of environmental services to livelihoods and the economy.

International organizations like the World Bank Group have a crucial role to play in linking project level and country level indicators through a consistent monitoring system that can aggregate information at the project level up to a scale that reaches country relevance. The new Environment Strategy provides the opportunity to move forward the monitoring agenda.

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<sup>1</sup> The Equator Principles (EPs) are a voluntary set of standards for determining, assessing and managing social and environmental risk in project financing. The Equator Principles in full can be found at : [http://www.equator-principles.com/documents/Equator\\_Principles.pdf](http://www.equator-principles.com/documents/Equator_Principles.pdf)

## Introduction

The world faces unprecedented environmental challenges over the coming decades, challenges that will significantly increase the complexity countries face in their work to achieve environmentally sustainable development. The proposed new World Bank Group (WBG) Environment Strategy aims at more effectively supporting countries in their work to achieve sustainable development by helping them devise the means to leverage natural resources for growth and poverty reduction, manage the environmental risks to growth and development, and transform growth paths.

A natural outgrowth of this kind of revitalized strategic focus, both at the country level and within the WBG institution, is the need to ensure effective monitoring of the impact of environmentally related actions and trends on development across the broad swath of development concerns.

As part of the WBG's new strategy to increase the effectiveness of its support to client countries in this regard, the WBG is considering a number of improvements, one of which includes a more effective measure of its own activities and results, and potential contribution to country-based measurement and monitoring at the country level. This focus is supported by results of stakeholder consultations and the WBG internal reform agenda, which call for renewed efforts to measure and monitor development effectiveness. Building on the internal reform, the strategy includes a results framework that pushes for measurement of outcomes.

This paper provides background to the strategy on this issue in order to help bolster the country- and global-level capacity for effective monitoring of environmental impacts on development. To achieve this, the paper presents four sections:

1. Overview of the global context in which drivers of environmental and development decision-making are affected by actions and circumstances.
2. Review of the major environmental and natural resource issues at the global level.
3. Identification of data and indicator sets available at the global and country levels to inform and advise decision-making and to identify critical data gaps.
4. Recommendations for actions in four areas in the short-term to improve monitoring of environmental and natural resource issues:
  - Application of information and communication technologies (ICTs) to environmental management.
  - Private sector involvement.
  - Development of wealth accounting efforts worldwide.
  - Linking project- and national-level indicators.

## 1. The Global Context

For countries to effectively undertake environmentally sustainable development, they must have the means and capacity to effectively monitor the environment, documenting and analyzing the measurable data detailing the impact of environmental trends on development sectors. This is an essential aspect of governmental decision-making, but data and information on environmental issues at the local and national levels is scarce at best. Governments generally have very little information about the proximity of environmental thresholds for air, water, biodiversity and other natural resources, the extent to which their policies can alter ecologic equilibriums, and the extent to which production and livelihoods depend upon such equilibriums to become sustainable. Compounding the problem, environmental degradation often has transboundary dimensions or the capacity to affect future generations, factors which can reduce incentives for action.

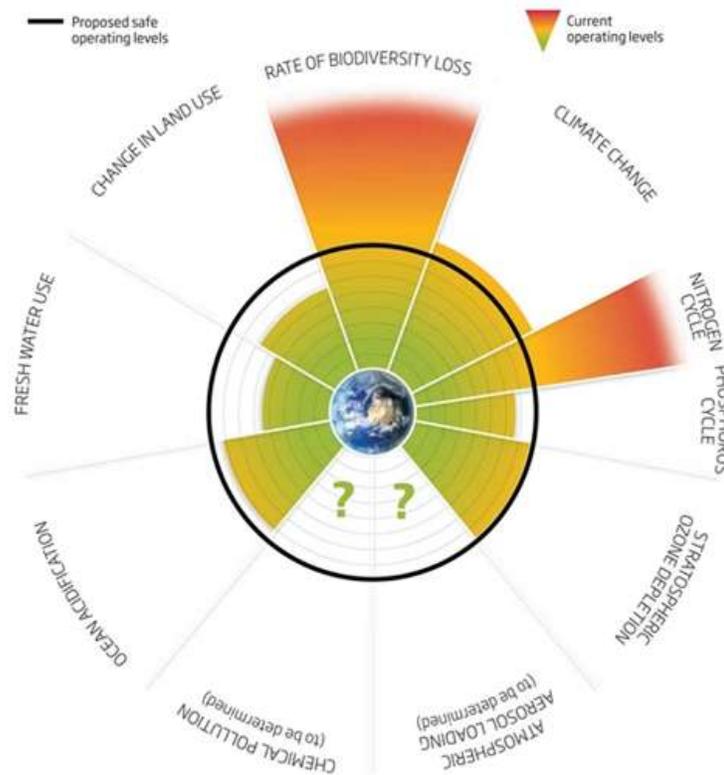
The world has now surpassed or is about to surpass a number of ecological boundaries. Rockstrom et al, 2009, defines nine “planetary boundaries within which we expect that humanity can operate safely. Exceeding one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems.” (See Fig. 1.) Of the nine planetary boundaries identified, the world has already gone beyond three: climate change, rate of biodiversity loss, and changes to the global nitrogen cycle. It is very close to surpassing two more boundaries: stratospheric ozone depletion and ocean acidification. Unfortunately, very little is known today about the implications of surpassing ecological boundaries and even less is known about the potential impacts on people and the economy. What seems clear is that planetary boundaries are interconnected. Going beyond one boundary may both shift the position of other boundaries and cause them to be surpassed. In addition, it may affect the need for faster adaptation by societies.

This report serves two purposes. First it provides an assessment of the status and trends of the world’s environment, reviewing existing models in the literature to describe major trends in environmental and natural resources issues over the next 20 years. In this regard, it is intended to give a sense of urgency and priority, at least at the global level. Second, it provides a global stocktaking to identify information and data gaps in environmental monitoring. It concludes with a number of suggested actions for the short- and medium-term that could help bridge the gap between supply and demand of information for environmental management.

The report does not advocate for any specific definition of environmental sustainability or normative framework for countries to follow. Rather, it works with the following premise as an underlying driver: regardless of a country’s requirements in terms of environmental sustainability and priority setting, it is important to identify the suite of indicators available and determine if they are sufficient to put a specific strategy in place and monitor progress in implementation.

**Figure 1: Beyond the boundaries**

We have already overstepped three of nine planetary boundaries and are at grave risk of transgressing several others



Source: Rockstrom et al, 200.

## 2. The world's environment – State and trends

This section provides a scan of the state of the global environment and analyzes trends in environmental and natural resource issues over the coming decades. This part of the report is based on a desk review of recently published reports by various international organizations such as the Organization for Economic Cooperation and Development (OECD), World Health Organization (WHO), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), and the World Bank.

### a. Drivers of environmental stress

The world faces increasing environmental stress driven by the evolution of population and urbanization and the resulting energy, transport and development trends at country and global levels. An analysis of each of these stresses follows.

## Population

In the second half of the 20th century the world population underwent unprecedented growth from 2.5 billion in 1950 to 6 billion in 2000. At the same time, however, the population growth rate was declining because of a drop in fertility rates from 5.1 to 2.6 births per woman by 2000. As a result, the world population is expected to grow more slowly than in previous decades, at one percent a year, during 2005-2030. But most developing countries will not benefit from this decline: between 2005 and 2030 roughly three billion people will be added to the world, and most (90 percent) will be born in low- and middle-income countries. Eighty-nine percent of the urban population growth of 1.8 billion people between 2005 and 2030 will occur in non-OECD countries (OECD 2008, **Error! Reference source not found.**). The fastest growing region will be Sub-Saharan Africa, and the largest number of people will be added to in Asia.

**Table 1: World population growth, 1950-2030**

Country groups	Population (billions)					Average annual rate of change (%)	
	1950	1975	2000	2005	2030	1950-2005	2005-2030
<b>Total population</b>							
World	2.52	4.07	6.09	6.46	8.20	1.73	0.96
OECD	0.68	0.92	1.14	1.17	1.30	0.99	0.40
BRIC	1.07	1.79	2.61	2.75	3.26	1.73	0.68
The ROW	0.77	1.36	2.34	2.54	3.64	2.20	1.45
<b>Urban population</b>							
World	0.73	1.52	2.84	3.15	4.91	2.69	1.79
OECD	0.37	0.62	0.84	0.88	1.07	1.59	0.75
BRIC	0.20	0.45	0.99	1.11	1.77	3.18	1.89
The ROW	0.16	0.45	1.01	1.16	2.07	2.84	2.37

Source: OECD 2008, p. 111

Population growth can hinder wealth accumulation, let alone natural capital which does not typically increase in physical terms. Table 2 shows estimates of changes in wealth per capita for a selected group of countries. Wealth is measured here as the monetary value of all assets in an economy, including physical capital, natural capital, human capital, social and institutional capital (World Bank, 2011 forthcoming). Through population growth, wealth gets diluted over time, resulting in negative changes in wealth per capita. Some developing countries such as Brazil, Pakistan and Algeria, but also some developed countries such as United States and New Zealand, are a case in point. It is also possible to estimate by how much wealth accumulation should increase to overcome the population dilution effect. This indicator goes under the name of 'saving gap', which is a measure of how much extra saving effort would be required for a country to break even with zero change in wealth per capita. The saving gap for Brazil in 2005 was 3.5 percent of Gross National Income (GNI). So, in order for wealth per capita to at least stay constant, saving in Brazil should have been gone from the actual rate of 7.8 percent to 11.3 percent. Of the countries in Table 2, the largest saving gaps are the ones for El Salvador (4.7 percent), followed by Zambia (4.6 percent) and Cambodia (4.4 percent). The saving gap for the United States and New Zealand is 2 percent.

**Table 2: Change in wealth per capita and saving gap in selected countries, 2005**

Country Name	Population growth rate (%)	Change in Wealth per capita	Adjusted Net Saving Gap (% of GNI)
El Salvador	1.8	-113	4.7
Zambia	1.7	-26	4.6
Cambodia	2	-19	4.4
Brazil	1.4	-163	3.5
Pakistan	2.4	-24	3.4
Dominican Republic	1.6	-104	3.1
Algeria	1.5	-69	2.3
United States	0.9	-821	2
New Zealand	0.9	-501	2
Chile	1.1	-129	1.9

Source: World Bank 2011 (Forthcoming)

### Urbanization and access to basic services

The urban/rural population split is changing rapidly. Thirty years ago, about 38 percent of the world's population lived in cities. By 2008, more than 50 percent (3.3 billion people) did. A third of urban dwellers (more than one billion people) now live in slum areas that lack basic social services. By 2030, 60 percent of the world's population (almost five billion people) are projected to live in urban areas, and most of this growth will be concentrated in smaller cities in developing countries and in megacities of unprecedented size in Southern and Eastern Asia. Globally, the urban area expanded by 171 percent between 1950 and 2000, and will increase by another 150 percent by 2030.

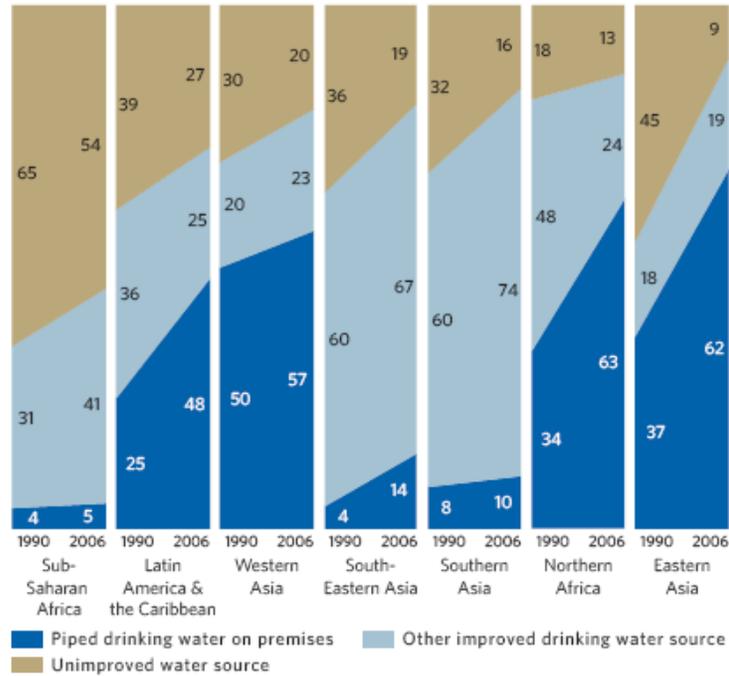
The rapidly expanding global population will increase the demand for energy, food, products and water resources. Continuing urban settlement will put huge pressure on the environment through land use stress, fragmentation of natural habitats, soil degradation, and increases in greenhouse gas (GHG) emissions and air pollution. Considering that most of the urban population growth will occur in developing countries, the impacts on environmental and human health will be much greater in these regions and these impacts are likely to differ by socioeconomic status and sex. The building and demolition activity in the housing and building sector generates waste and absorbs between one-third and one-half of worldwide commodity flows in terms of weight (OECD 2008, p. 116). And yet, infrastructure development is insufficient in many urban areas and it is unable to meet the population growth rate of urban settlements.

Inhabitants of developing countries, particularly those in the poorest households, often experience very low rates of access to basic services. The provision of basic health, education and other essential services depends on the availability of basic infrastructure services such as electricity, water and sanitation, but data indicate that many countries lack these basic services. And in some countries infrastructure is deteriorating: 884 million people, almost all of them in developing countries, do not use improved sources of drinking water (MDG 2009, p. 46). Roughly 84 percent of those affected live in rural areas (Figure 2) and women and girls bear the

brunt of most household water collection, particularly in Africa. Twenty-seven percent of rural population had access to piped water to their homes, and 23 percent obtained their drinking water from insufficient sources. Fifty percent of the rural population was supplied by public taps, hand pumps and wells. These figures differ by regions. Most undeveloped is Sub-Saharan Africa.

**Figure 2: Access to improved drinking water sources in rural areas**

Proportion of rural households using piped water, other improved sources and unimproved sources, 1990 and 2006 (Percentage)



Source: MDG 2009, p. 46

More than 5 billion people (67 percent of the world population) are expected to be without a connection to public sewerage in 2030 – 1.1 billion more than in 2008 – and freshwater in urban and rural areas is becoming scarcer (OECD 2008, 220). Open defecation is a problem with respect to water safety. Eighteen percent - of which 87 percent live in rural areas – of world’s population practice open defecation (MDG 2009, p. 45). Still 2.6 billion people do not have improved sanitation access (WHO/UNICEF 2010, p. 6). Disparities between urban and rural sanitation supply are large. Seven out of ten people without improved sanitation live in rural areas (WHO/UNICEF 2010, p. 16). Also, access to sanitation is lowest in Sub-Saharan Africa, followed by Asia (WHO 2010).

In developing countries, many poor people suffer from a lack of access to modern energy. Nearly 75 percent of Sub-Saharan Africans, or 550 million people, do not have access to electricity. In South Asia, some 50 percent, or 700 million people, lack access. About 90 percent of those without access in South Asia live in rural areas. The International Energy Agency estimates 1.4 billion people will still lack access to electricity in 2030 unless new approaches and policies are adopted. Successfully tackling electrification means adapting programs to local contexts and national environments.

## Manufacturing, commodity use and waste

According to the OECD Outlook baseline, the global economy is projected to grow by nearly three percent a year from 2005 to 2030 (OECD 2008, p.76). Growth will mainly be driven by BRIC<sup>2</sup> countries (4.6 percent) and other developing countries (four percent). Manufacturing will continue to account for the largest share of output in BRIC countries through the second and third decades of the century, even if it will decline in relative terms, from 44 percent of gross economic output in 2001 to 37 percent in 2030. Manufacturing will also continue to be very important in other developing countries as well, although it will decline in relative terms from 38 percent in 2001 to 31 percent in 2030<sup>3</sup>. This means that resource extraction and fuel combustion will likely continue at a high pace over the coming decades.

Global resource extraction has increased immensely during the last decades, from 40 billion tonnes in 1980 to 58 billion tonnes in 2005 (WRF 2010) and, according to some projections, will rise to 80 billion tonnes in 2020 (OECD 2008, p. 239). Utilization of non-renewable resources, and especially metal ores and non-metallic minerals, will increase the most. Use of metal ores exhibits the sharpest increase. It is expected to double between 2000 and 2020 to more than 11 billion tonnes (OECD 2008, p. 239). Extraction of biomass is expected to grow by 30 percent in the same period. The main factors affecting long-term global demand for wood products include demographic change and increasing economic growth. The production of panel wood, industrial round wood, firewood as well as paper and paperboard products will constantly rise in the future; driving this will be China and India, but also other rapidly growing economies (FAO 2009b).

As a consequence of growing demand for materials, the amount of waste generated by economic activity is continuing to rise as well. By 2030 non-OECD countries are projected to produce 70 percent of the world's municipal waste. In 2030 the mean daily per capita municipal waste generation in OECD countries will be 1.8 kg<sup>4</sup> compared to 1.5 kg today, 0.75 kg in the BRIC countries plus Indonesia and South Africa (BRIICS) compared to 0.4 kg today, and 0.9 kg compared to 0.7kg today in the rest of the world. Total waste generation will be 900 million tonnes in OECD countries, 1 billion tonnes in BRIICS, and 1.1 billion tonnes in the rest of the world by 2030. But Brazil, Russia, Indonesia and South Africa have already exceeded the BRIICS projected amount by 2030. China and India have not reached that level yet, although China has a 1.2 kg/capita/day ratio in cities. As part of the waste management challenge, harmful substances and hazardous waste constitute a considerable risk for human health and the environment. But landfill waste disposal is still a widespread practice (in 2005 49 percent of municipal waste was destined for landfills in OECD countries).

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<sup>2</sup> BRIC countries are Brazil, Russia, India, and China.

<sup>3</sup> Services will increase their relative importance from 25 percent to 37 percent in BRICs and from 28 percent to 38 percent in other developing countries (OECD 2008, p.85).

<sup>4</sup> Municipal waste generation has already stabilized in OECD countries (OECD 2008, p. 246)

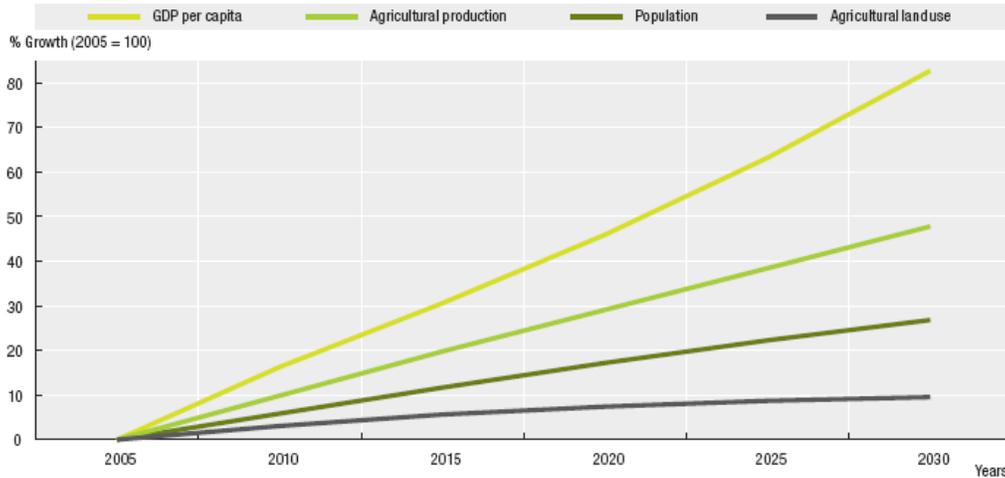
## **Food, agriculture and fishing**

Given the projected population expansion by 2050, and the need to meet the Millennium Development Goal (MDG) on hunger, a doubling of food production could be required (UNEP 2007, p. 110). The livestock sector is one of the fastest growing parts of the agricultural economy, driven by income growth and technological change (FAO 2009). Grazing and cropland dedicated to feed production presents almost 80 percent of all agricultural land (FAO 2009). The shift from cereal to meat consumption alone could increase agricultural production by roughly 50 percent between 2005 and 2030 (OECD 2008, p. 297, Figure 3). Livestock grazing occupies 26 percent of the ice-free land surface and the livestock feed production consumes 33 percent of agricultural cropland (Steinfeld et al. 2006). Demand for livestock is most responsive to income growth in low-income countries, and even though prices might get even higher and more volatile (IFPRI 2008), the potential for increasing per capita consumption of livestock is huge (FAO 2009). Cattle population is projected to increase from 1.5 billion to 2.6 billion and that of goats and sheep from 1.7 billion to 2.7 billion between 2000 and 2050.

Macroeconomic, population and technological developments and availability of land in developing countries mean that agricultural production is growing four times faster than in OECD countries (OECD 2008). Per capita consumption of agricultural products are expected to grow by 70 percent in developing countries – mainly in BRIC countries – by 2030 (OECD 2008). Oilseed production is projected to grow 50 percent faster than overall average agricultural production to 2030, boosted by rising demand for vegetable oils for human consumption and oilseed meal for feeding animals (OECD 2008). Biofuel cultivation, which occupies one percent of arable land today, will increase fourfold by 2030 (World Bank 2010, p. 147). It is projected that the share of biofuel of total transport fuel will increase slightly from two percent in 2006 to four percent in 2030 (OECD 2008). However, it remains unclear to what extent demand for biofuels will rise between now and 2030.

Climate change could slow down the growth in agricultural products. A model predicts that by 2080 world agricultural productivity will decline three percent under a high-carbon emission scenario, assuming carbon fertilization, or 16 percent without it (Cline 2007). But the impacts will be unevenly distributed; in fact for the developing world the decline is even larger, between nine percent and 21 percent respectively. In addition, the arable land available for agriculture could be reduced heavily in the period to 2080. Sub-Saharan Africa is one of the most vulnerable regions with respect to climate change. Impacts, mainly in the agricultural sector, will cause losses between two and seven percent of GDP (World Bank 2008). Droughts, floods and pest outbreaks will harm agriculture production and food systems.

**Figure 3: Expected growth of world population, GDP per capita, agricultural production and land use (Percentage change from 2005-2030)**

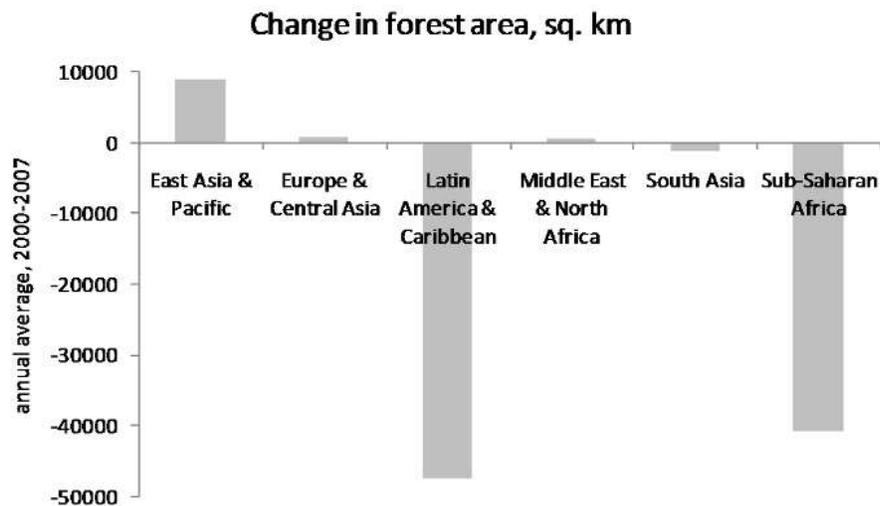


Source: OECD 2008, p. 297.

In developing countries, the net loss of forest area for 2000-07 is estimated at 80,000 square kilometres a year. Sub-Saharan Africa, Latin America and the Caribbean, and South and East Asia continue to account for the largest net losses of forests (Figure 4). Women, who have greater responsibilities for household fuelwood collection, will be disproportionately affected by reduced forest areas and access.

Between 2005 and 2030 another 13 percent of naturally forested area is expected to be lost worldwide (OECD 2008, p. 204). Illegal logging continues to threaten rain forests and biodiversity: 8-10 percent of global industrial round wood production is sourced illegally (OECD 2008, p. 206). Plantation forests accounted for 22 percent of global roundwood harvest in 2000 and this trend is going up (OECD 2008, p. 205).

**Figure 4: Change in forest area in developing regions, 2000-2007**



Source: World Bank 2010

Fisheries and aquaculture are essential suppliers of animal protein to human beings and also provide livelihood opportunities throughout the value chain. Over 500 million women and men directly and indirectly depend on fisheries and aquaculture for their livelihood (FAO 2010). Over the next decade, while the catch from capture fisheries will remain roughly constant in quantity, it will likely decline as a share of total fisheries production. Between 25 percent and 30 percent of marine fish stocks are overexploited and about 50 percent are fully exploited at their maximum sustainable yield (MDG 2009). Since fish protein is of high value and demand will increase due to increasing incomes and population, aquaculture is expected to fill the gap in fish supply. Since fish currently supplies eight percent of the world protein consumed, fish and shellfish production has to grow by about 2.2 million metric tonnes every year to meet the increase in demand. Aquaculture contributes already with 46 percent to total fish supply and has an annual growth rate of 7 percent. Between 2010 and 2030 it is expected to grow, according to some models, at around 4.5 percent annually (FAO 2004).

### **Energy and transport**

According to the OECD Outlook baseline, global primary energy consumption is projected to increase by 1.8 percent annually between 2005 and 2030 and 1.0 percent between 2005 and 2050 (see Table 3). The total share of fossil fuels in energy use remains constant at about 85 percent between 2005 and 2030 and drops a bit to 80 percent in 2050 (OECD 2008, p. 361). In projection, modern renewables (geothermal, solar, wind, tidal energy and biofuels) will contribute a modest 1 percent in 2005 and 4 percent up to 2030 (ibid, p. 365). The expected 4 percent annual rise in demand for electricity between 2005 and 2030 will be fed mainly by coal plants, increasing from 46 percent to 55 percent share in total energy generation between 2005 and 2030 (OECD 2008, p. 365). The share of gas will rise from 21 percent in 2005 to 27 percent in 2030 (ibid, p. 365). Per capita energy consumption will likely be still higher in OECD countries up to 2030 but total energy consumption will be led by non-OECD countries (World Bank 2010, p. 194, Figure 5). The energy consumption in final-use sectors – industry, transport, residential, services, and agriculture – is projected to increase from 308 Exajoule (EJ) in 2005 to 472 EJ in 2030. Per capita final energy consumption is estimated to rise in all regions between 2005 and 2030 (20 percent OECD, 32 percent BRIC, and 36 percent rest of world (ROW).

The energy sector requires huge investments to meet future energy demand. Total investments between 2005 and 2030 are projected to amount to around USD 20 trillion or USD 800 billion per year (IEA 2006). The major task will be to further develop energy efficient technologies in the consumer and power generation sectors. Hybrid and hydrogen fuel cells vehicles and zero-energy buildings are some of the investment opportunities with high potential. The power generation industry will have to innovate further in solar photovoltaic, long-distance electricity transportation and geothermal electricity generation and this will provide enterprise and employment opportunities for women and men.

**Table 3: World primary energy consumption (EJ), 1980-2050**

					Compound annual growth rate (%)		
	1980	2005	2030	2050	1980-2005	2005-2030	2030-2050
Coal	75.5	129.0	198.1	224.2	2.2	1.7	0.6
Oil	132.4	168.1	239.0	287.8	1.0	1.4	0.9
Natural gas	55.3	98.1	174.9	221.4	2.3	2.3	1.2
Modern biofuels	0.5	2.2	16.4	39.1	6.1	8.4	4.5
Traditional biofuels	33.5	44.4	52.8	50.7	1.1	0.7	-0.2
Nuclear <sup>a</sup>	2.5	9.3	12.9	12.1	5.4	1.3	-0.4
Solar/wind	0.1	0.6	4.9	12.6	7.9	9.1	4.9
Hydro	6.0	10.5	15.1	17.6	2.3	1.5	0.7
Total	305.8	462.3	714.2	865.4	1.7	1.8	1.0

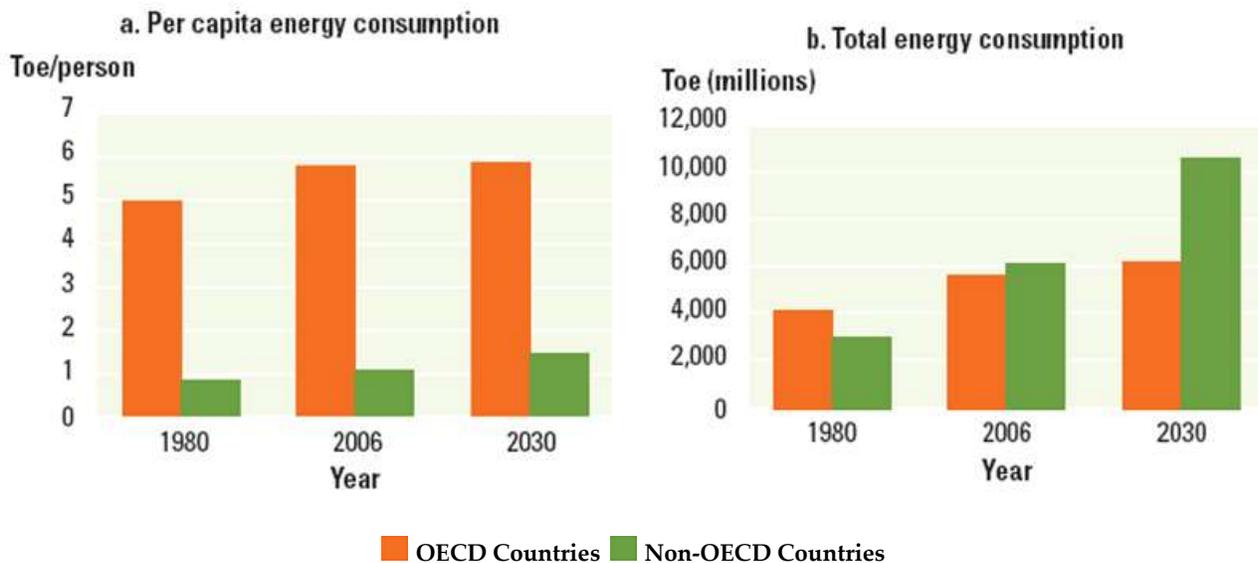
StatLink  <http://dx.doi.org/10.1787/257501561404>

a) These numbers differ by approximately a factor of three from those reported by the International Energy Agency (IEA). This is because the IEA defines the amount of primary nuclear energy consumption as three times the amount of energy produced in the form of electricity – this is the “fossil fuel replacement method” to report primary energy supply associated with this energy carrier. We define all direct electricity options using a simpler method, on the basis of electricity output.

Source: OECD 2008, p. 361

The rapid increase in transportation that took place in the past decades will likely continue and intensify in the coming years. According to some predictions, global transport energy use and CO<sub>2</sub> emissions from transport could increase by nearly 80 percent between 2009 and 2050 (UNEP 2010, p. 58). Global CO<sub>2</sub> emissions from the transport sector are expected to expand from 6.1 GtCO<sub>2</sub> in 2005, to 9.6 GtCO<sub>2</sub> in 2030 and 12.2 GtCO<sub>2</sub> in 2050 (OECD 2008, p. 144). This doubling by 2050 occurs as the demand for cars increases, particularly in developing countries. Globally, car ownership will grow by 2.3 billion cars between 2005 and 2030 (World Bank 2010, p. 194).

**Figure 5: Per capita energy consumption and total energy consumption**



Source: World Bank 2010

## **b. Evolution of environmental impacts**

Under the pressure of increasing population, urbanization, energy, transport and agricultural development, the world's environment will face unprecedented challenges over the coming decades. This section looks at the foreseeable future and assesses the impacts across environmental issues, from those that are felt on a global scale with global externalities, such as global warming and biodiversity loss, to those felt also on a local scale, such as urban air pollution and water pollution.

### **Global scale impacts**

#### *GHG emissions and their impacts on livelihoods, production and oceans*

According to OECD's Outlook baseline, global GHG emissions will increase by about 37 percent between now and 2030, and by 52 percent between now and 2050 (Table 4). Under the same scenario, in developing countries emissions growth will be significantly higher than in OECD countries. Emissions per capita will increase in all regions, while emissions per unit of GDP will decline. Industrialized countries will continue to have the highest emissions per capita, but will continue to have on average the lowest emission intensity of GDP<sup>5</sup>. Methane emissions will increase by 32 percent, and to 47 percent in 2030 and 2050 compared to the 2005 level (OECD 2008, p. 146). N<sub>2</sub>O emissions are expected to increase by about 20 percent to 2030 and 26 percent to 2050 compared to 2005 levels. Other gases like hydrofluorocarbon (HFC) and perfluorocarbon (PFC) from industrial processes, which have a high global warming potential, will double and quadruple in levels from 2005 to 2030 and 2050 and it is projected that they will contribute roughly 4 percent of the total change in GHG emissions from 2005 (OECD 2008, p. 146).

To have a 50:50 chance of limiting global temperature increase to 2°C above preindustrial levels will require stabilization of GHG concentration of approximately 450 ppm CO<sub>2</sub>e. A 550 ppm CO<sub>2</sub>e stabilization level would reduce the probability of reaching the threshold level to 20 percent. Avoiding dangerous climate change will require rich countries to cut emission by 80 percent by 2050, 30 percent by 2020. GHG emissions from developing countries would need to be cut by 20 percent by 2050. To meet this stabilization target would cost 1.6 percent of global GDP annually between 2008 and 2030 (UNDP 2008).

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<sup>5</sup> An important caveat is in order. GHG intensity of some industrialized countries (in particular high-emitting countries such as the US or Australia) is higher than that of some developing countries with low levels of industrial activities or those relying on hydropower for electricity generation.

**Table 4: Global emissions by region and GHG intensity indicators: 2005, 2030, 2050**

	2005	2030	2050
All GHG – Gt CO <sub>2</sub> eq			
OECD	18.7	23.0	23.5
BRIC	16.1	23.5	26.2
ROW	12.1	17.6	21.7
<b>World</b>	<b>46.9</b>	<b>64.1</b>	<b>71.4</b>
Change in GHG, 2030 and 2050			
		% increase	% increase
OECD	Base year	23%	26%
BRIC	–	46%	63%
ROW	–	45%	79%
<b>World</b>	–	<b>37%</b>	<b>52%</b>
Shares of total GHG by region			
	% share	% share	% share
OECD	40%	36%	33%
BRIC	34%	37%	37%
ROW	26%	27%	30%
CO <sub>2</sub> eq per capita (T/person)			
OECD	15.0	16.8	17.0
BRIC	5.1	6.1	6.4
ROW	5.8	5.9	6.0
<b>World</b>	<b>7.2</b>	<b>7.8</b>	<b>7.8</b>

Source: OECD 2008

World regions will be affected differently by the changing climate, as will different social groups and men and women within these regions. Climate change will affect numerous productive environments, including agriculture, forestry and coastal zones. Warming can have a big impact on both the level and growth of GDP. It has been shown that anomalously warm years reduce current level and subsequent growth rate of GDP in developing countries (Dell et al. 2008). Most heavily affected will be agricultural yields – due to global warming and variations in rainfall. Heat waves could add to the toll not only in agriculture but also through damages to fisheries and human health.

Further spread of disease, e.g. malaria, will hit the African continent (World Bank 2010, p. 6). Dry areas will become dryer and wet areas wetter due to temperature rise between 3-4 degrees by 2099 (World Bank, 2010a). In the Asia and the Pacific region, countries which are highly dependent on marine resources will be further stressed by increasing water temperature, precipitation patterns will be distorted dramatically and Himalayan glacier will suffer from severe retreat. Coastal areas are under threat of rising sea level. Latin America will be hit hard by melting glaciers. High income countries and developing countries alike will be affected by climate change, although wealthier countries will be able to cope with changes better.

Oceans are affected by acidification as a consequence of higher CO<sub>2</sub> concentration in the atmosphere. Acidification also poses a challenge to marine biodiversity and destabilizes the function of oceans as carbon sinks; they remove roughly 25 percent of human emissions (Rockström et al. 2009). Oceans store more than 450 billion tonnes of CO<sub>2</sub> from the atmosphere

(UNEP 2010, p. 36). This process leads to changing pH values which deteriorate corals and threatens marine fish habitats.

### ***Biodiversity loss***

The world is now experiencing the sixth major extinction event in the history of life on Earth (Rockström et al. 2009). As previous extinction events, it is likely that the current process will result in massive permanent changes in the functioning and status of Earth's ecosystems. Of 24 ecosystem services examined in a World Bank study, 15 are being degraded or unsustainably used (World Bank 2010, p. 124).

If deforestation, agricultural activities, population growth and pollution continue increasing, there is a high risk of dramatic loss and degradation of a broad range of ecosystem services. The poor would face the most severe impacts of such changes. Examples include (Convention on Biological Diversity (CBD) 2010):

- Amazon forest dieback, caused by deforestation, fire and climate change, which would cause parts of the forest being affected by a self-perpetuating cycle of more frequent fires and intense droughts.
- Build-up of phosphates and nitrates from agricultural fertilizers and sewage effluents, which can shift freshwater ecosystems in a long-term, algae-dominated eutrophic state.
- Collapse of tropical reef ecosystems, caused by the combined impact of ocean acidification, warmer sea temperatures and other human induced stresses, resulting in catastrophic losses of ecosystem functioning and food security.

Protected areas are the cornerstone of efforts to conserve ecosystems and species. In 2008, 12 percent of the planet surface was under some form of protection (MDG 2009, p. 42). Even if the world's reserve network quadrupled between 1970 and 2007, this area would be inadequate to conserve biodiversity (World Bank 2010, p. 152). Forests play a crucial role in biodiversity conservation, but targets adopted to protect the world's forests will not be met by 2010 (UNEP 2010, p. 14).

A number of planetary changes can affect biodiversity, regardless of the success of the protection regime. Climate change is transforming ecological systems and it will severely affect biodiversity by 2100. For many species, temperatures will increase too fast to allow them to adapt to warmer environments. With 3°C of warming, 20-30 percent of land species could be extinct (UNDP 2008, p. 10). Estimates show that 10% of species will be lost for each 1°C rise in temperature (World Bank 2010, p. 124). Climate change can change disease distribution in fauna and flora, precipitation, competition over habitat space, and on food supply for specific species. These changes will have differential impacts on men and women, particularly when women have responsibilities for family nutrition and health care using wild plant and animal resources.

### *Exposure to other disasters*

Natural disasters, such as earthquakes, floods, tsunamis, and landslides, are sudden events caused by nature that adversely affect a large portion of the population or the economy. Global warming, ocean acidification and biodiversity loss can also lead to large-scale impacts.

Over the past few decades, a growing number of natural disasters have taken an increasingly devastating toll on people's lives and livelihoods and on physical infrastructure. Between January 1975 and October 2008 and excluding epidemics, the International Emergency Disasters Database EMDAT recorded 8,866 events killing 2,283,767 people. Of these, 23 mega-disasters killed 1,786,084 people, mainly in developing countries. In other words, 0.26% of the events accounted for 78.2% of the mortality. In the same period, recorded economic losses were \$1,527.6 billion. Of the ten disasters with the highest death tolls since 1975, no fewer than half have occurred in the five-year period between 2003 and 2008. Four of the ten disasters with the highest economic losses occurred in the same period (International Strategy for Disaster Reduction (ISDR), 2009).

The economic costs of major disasters in constant dollars are now estimated to be 15 times higher than they were in the 1950s (IMF, 2003). In addition, women have been disproportionately negatively affected by disasters due to sex-related gender norms related to mobility, shame and loss of assets.

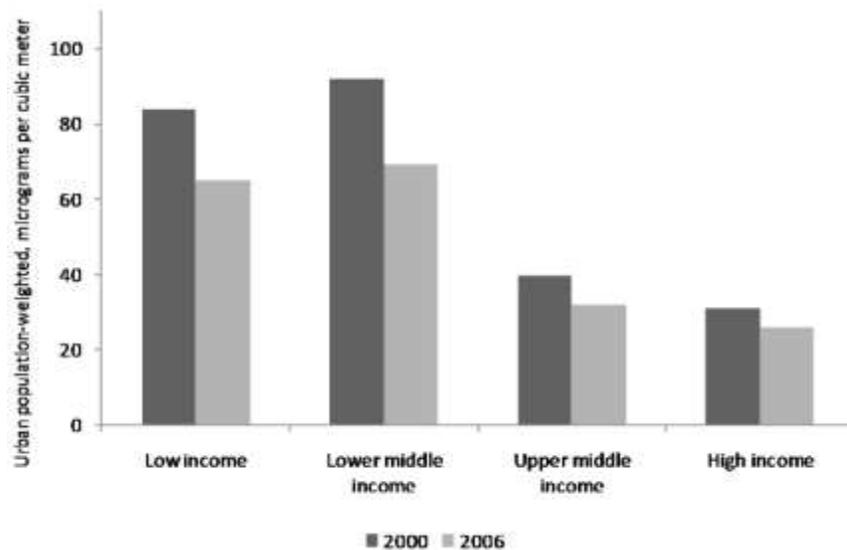
Scientists believe that this long-term upward trend is the result of more frequent disasters, a growing global population that continues to expand its economic assets and often lives in increasingly vulnerable areas, and continued environmental degradation. But most importantly, the economic and human costs of natural disasters are tightly connected with development. Losses to disasters in developing countries are generally much higher than in developed countries, as a percentage of GDP.

### **Local scale impacts**

#### *Urban air pollution*

With ongoing urbanization and ageing, the effect on urban citizens from urban air pollution will continue to be high throughout 2030. While there are signs of improvements (World Bank, 2010b), concentration levels of particulate matter (PM) in low and lower middle income countries are still three times higher than in high-income countries (Figure 6). In many regions, the deterioration of urban air quality still exceeds the global health-related target (OECD 2008). The levels of suspended particles in Asia, Africa and Latin America are higher than in Europe and North America (WHO 2006). Asia has the highest emission levels, with the annual average PM10 microgram ( $\mu\text{g}$ ) concentrations in selected cities ranged from about 35  $\mu\text{g}/\text{m}^3$  to 220  $\mu\text{g}/\text{m}^3$ .

**Figure 6: Annual pm10 concentration by income group, 2000-2006**



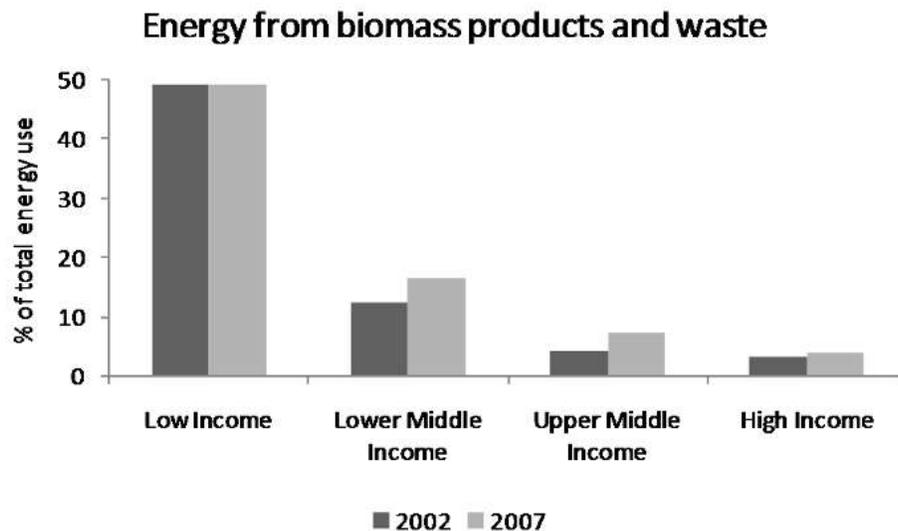
Source: World Bank 2010b

Severe health effects are caused by air pollution. Impacts from toxic and carcinogenic pollutants, such as cardiovascular and respiratory diseases and lung cancer, are serious threats. In 2000 exposure to PM10 and PM2.5 caused approximately 960,000 premature deaths and 9.6 million years of life lost worldwide (OECD 2008, p. 257). For 2030, the estimated worldwide number of premature deaths and years of life lost is projected to be 3.1 million and 25.4 million, respectively. Ground level ozone concentrations are expected to increase, especially in urban areas, with an impact on vegetation and human health. Overall, the hemispheric background concentration of tropospheric ozone is increasing. Rising concentrations have been recorded for North American and European cities, and levels exceeding WHO's 2000 guideline values have been reported from cities in Mexico, Latin America, Africa, Australia and Europe.

### ***Indoor air pollution***

In addition to atmospheric air pollution, indoor air pollution from burning traditional fuels in spaces that lack proper ventilation poses serious health risks to humans, especially for women and girls involved in cooking over wood and charcoal. The lack of access to modern sources of energy continues to be an important health risk factor in the poorest countries, where nearly 50 percent of energy use comes from biomass fuels and waste (Figure 7). The most common of such fuels are wood, agricultural residues, animal dung, charcoal, and (in some countries) coal. It accounts for more than 1.5 million deaths each year, half of them below the age of five (UNDP 2008, p. 45). Women and children are particularly vulnerable. With 400 deaths per day, indoor air pollution is a more dangerous threat than malaria and can be compared with the severity of tuberculosis (UNDP 2008, p. 45).

Figure 7: Energy from biomass products and waste, 2002-2007



Source: World Bank 2010b

### *Water pollution*

According to the World Commission on Water, more than half of the world's major rivers are seriously depleted and polluted. This problem degrades and poisons surrounding ecosystems, threatening the health and livelihoods of people who depend on them. Sources of pollutants include untreated sewage, chemical discharges, petroleum leaks and spills, dumping in old mines and pits, and agricultural chemicals that are washed off or seep into the ground from farms. Similarly, groundwater resources are vulnerable to overuse and pollution.

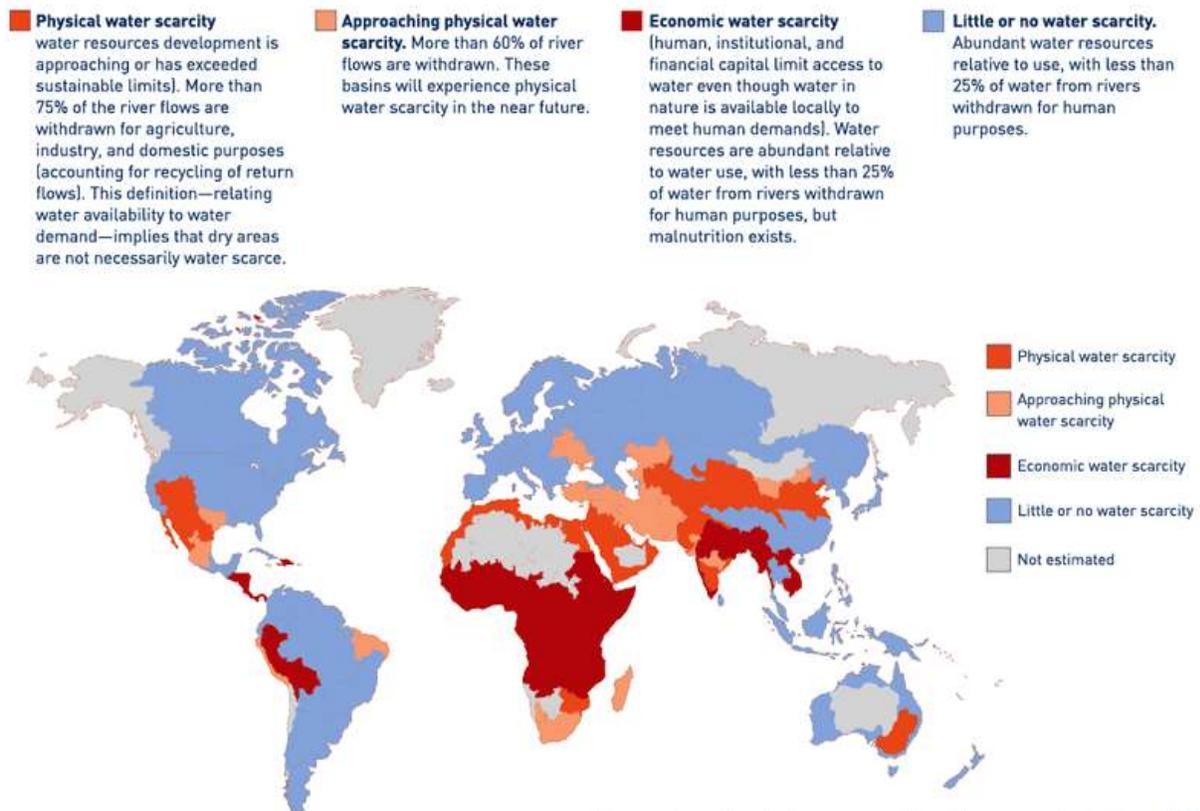
In various parts of Africa, water quality is impaired by industrial or mine effluents, sewage or sewage return flows, runoff of nutrients and pesticides from farmlands, and salinization as a result of inappropriate spray irrigation. In Europe and Central Asia, water quality and pollution concerns arise from nitrate overload in agricultural lands and phosphorous from domestic and industrial wastewater running off into seas, lakes, rivers, and groundwater. In some of the Central and Eastern European countries, groundwater pollution continues to be a serious problem, although the use of nitrogen-phosphorous fertilizers has steadily been curtailed and treatment of wastewater increased. Waters of the Adriatic, the Black Sea, the Baltic, and other closed or semi-closed seas are prone to a range of pollution dangers from shipping and a variety of land-based sources. In Latin America and the Caribbean, agricultural wastes and industrial discharges are key sources of water pollution. Untreated urban sewage is a problem in and around big cities. Oil and gas industry activities pose some threat to marine and coastal ecosystems, and urban growth and tourism infrastructure have physically altered coastal areas. Asia and the Pacific countries are facing problems due to pollution and inadequate supply of improved water and sanitation. In South and Southeast Asia, the Yellow, Ganges, and Amu Darya Rivers top the list of the world's most polluted rivers (World Commission on Water, 1999).

## Water scarcity

Increasing population and growing urbanization in developing countries will also increase demand for public water supply. By 2030, exposure to severe water stress in developing countries is projected to increase by one billion people from the current 3.9 billion people (OECD 2008, p. 220).

Water scarcity is most prevalent in Sub-Saharan Africa, Middle East and South Asia, and increasingly in North America, but also China and India (Figure 8). Africa experiences large spatial variations in rainfall, with 95 percent of the total falling in the central and south western wet equatorial zone. Water stress is widespread and is on the increase in many countries, undermining food security and human and animal health. Although Europe as a whole is rich in water, parts of Central and Eastern Europe and the Mediterranean countries suffer water stress and there are signs it is increasing. In Latin America and the Caribbean, the spread of irrigation systems in recent decades and wasteful and inefficient state-run irrigation systems has increased pressure on available water resources. In South America, especially Argentina and Brazil, a large proportion of water is used for industry, mostly the energy, mining, and petroleum sectors.

**Figure 8: Areas of physical and economic water scarcity**



Source: IWMI 2007

### *Land degradation*

Soil erosion risk will rise dramatically due to the increasing use of soils to support food production. Areas affected by soil erosion are projected to increase from 20 million km<sup>2</sup> in 2000 to almost 30 million km<sup>2</sup> in 2030 (OECD 2008, p. 225).

Land use and associated inputs and management are the main direct causes of land degradation. Agricultural lands (cropping, livestock rearing) are more susceptible to degradation than non-agricultural ones. Land use itself is determined by natural conditions and cultural and socio-economic aspects including institutional settings, infrastructure, education and market availability. 42 percent of the very poor live in degraded areas versus 32% of the moderately poor and 15% of the non-poor.

Land degradation due to agricultural and deforestation activities will heavily affect the African continent, which already shows the fastest degradation rate, with 70 percent of cultivated land already degraded (World Bank 2006a). The most severe degradation is occurring in Africa's forests, woodland and savanna ecosystems and is felt by the men and women who farm, collect and graze natural resources. Other regions will also be affected. In East Asia and the Pacific deforestation is an enormous problem associated with land degradation. Indo-China, Myanmar, Malaysia and Indonesia account for 6 percent of the global degraded area and South China is being followed with 5 percent. In the Middle East and North Africa water management and salinization from agricultural activity pose a major threat to land quality. 25 percent of the land area in the Caribbean and 15 percent of in South America fall into the category of severe degradation.

## **3. The Indicators Challenge – An Assessment**

The environment challenges identified in the previous section are serious and require immediate action. Action, in turn, requires information. This section reviews the availability of information about these environmental conditions and impacts, identifying data and indicator sets available at the global and country levels to measure demand identifying important data gaps. For each issue, available indicators were traced to identify data availability, gaps and possible opportunities for augmenting indicator sets for use in country operations and environmental economic work.

### **a. Indicator SOURCE review**

A summary of indicator sources available for the major environmental issues is presented below. A number of data portals presenting country-level data on a wide number of indicators are currently available from international organizations, such as the World Bank's World

Development Indicators<sup>6</sup>, the United Nations UN-Data<sup>7</sup> and UNEP's GEO Data Portal<sup>8</sup>. In addition, there are a number of specific global and country-level sources of data, as outlined below. (See Annex 1 for a detailed review.).

**Indoor air pollution.** Sources of indicators to trace indoor air pollution, comparable at the international level, include Index of Indoor Air Pollution compiled and published by WHO and community-level Indoor Air Pollution and Exposure Database compiled by the University of California at Berkley.

**Urban air pollution.** The major source for indicators of urban air pollution is the national data on urban population weighted PM10 levels in residential areas of cities published by the World Bank. Although a few countries have published national and regional Air Quality indices, they are not comparable. National data on emissions of carbon monoxide, nitrogen oxide, non-methane volatile organic compounds, and sulfur dioxide are available for selected years from the EDGAR database. An indicator to analyze the impact of air quality is the Disability Adjusted Years of Life (DALY) compiled and published by WHO. There is only limited data on air quality at the sub-national level; such data may be complemented by indicators attributable to specific pollution exposures.

**Climate change.** Indicators to track climate change include global mean surface temperatures and surface temperature anomalies. These are tracked using the GIS databases maintained by the US National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA) and the dataset on climate change maintained by the Intergovernmental Panel on Climate Change (IPCC) under the UN Framework Convention on Climate Change (UNFCCC). Other available indicators to trace GHG emissions are national data CO2 emissions per capita, CO2 emissions per GDP, residential CO2 emissions per capita compiled, total CO2 emissions published by the International Energy Agency (IEA); CO2 emissions from sources like cement production, gas flaring, gas fuels, liquid fuels and solid fuels; CO2 emissions from land-use change and non-CO2 GHG emissions compiled and published online for selected years by the Carbon Dioxide Information Analysis Center. Although climate change is a global environmental issue, efficient mitigation is targeted at national and local levels and hence sub-national and local data on GHG emissions could be useful in country economic work analyzing the carbon footprint of individual projects.

**Water quality and availability.** The national database on water quality compiled by the UNEP presents data for about 170 countries. UNEP also has a database on water quality for more than 100 countries with more than two million entries on water quality at the regional/local level. Indicators on water scarcity and access are included in FAO's AQUASTAT database in a water stress index, water balance index, water scarcity index, access to improved water and sanitation, and national data on water resources. The FAO database has data at the national level on a

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<sup>6</sup> <http://data.worldbank.org>

<sup>7</sup> <http://data.un.org>

<sup>8</sup> <http://geodata.grid.unep.ch>

number of indicators that determine the availability of water, water withdrawals for different uses and agricultural water use. National data on Disability Adjusted Life Years (DALYs) developed and maintained by WHO provides an indicator on water quality impacts on human health. There is limited comparable data on water quality, quantity and scarcity at the regional/sub-national levels.

**Land degradation.** Data on indicators of land and soil degradation include the global GIS-based GLASOD map on land degradation over the period 1987-1990 and the more recent ASSOD map on degradation for 16 countries in Southeast Asia over the period 1995-1997. The Normalized Difference Vegetation Index (NDVI) data set provides another indicator of land degradation and is available on 16 day basis for six years from 2001-2006. Another database and indicator set that is currently being developed by FAO is the Global Land Degradation Information System (GLADIS)<sup>9</sup> database with more than a thousand records of data, documents, maps, statistics etc. related to land degradation in drylands. Some of the indicators that could be used at the local/regional level to trace land and soil degradation are water logging, land use and cover, land-use compatibility index, economic productivity, poverty and food insecurity, crop yield forecasting and crop cover and land pollution. The works of different international agencies like FAO, GEF, World Bank, and UNEP could be coordinated to develop more comprehensive database on indicators of land and soil degradation.

FAO's database on annual percentage change in natural forest area, total forest area and forest plantations for 229 countries provides data on deforestation and forest conversion. Other databases with indicators of deforestation are the Landsat Pathfinder Humid Tropical Deforestation database, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and the Moderate Resolution Imaging Spectroradiometer (MODIS) database. Indicators of the causes of deforestation include data on urbanization, agricultural expansion, wood fuel and round-wood production. The review showed that there is limited data on degradation of forests.

**Natural disasters.** The review found databases on natural disasters at the global, regional and national levels. The global databases include the EM-DAT International Disaster Database with data since 1988, Global Disaster Identifier Number (GLIDE), the University of Richmond disaster database, British Association for Immediate Care (BASICS) database and private databases like NatCat maintained by Munich Reinsurance Company. The regional databases include the La RED database covering Latin America, and the Asian Disaster Reduction Center database covering Asia and Southeast Asia. The sub-national databases on disasters include the ones for South Africa, UNDP's database on Sri Lanka and Orissa state in India.

**Biodiversity.** Indicators of impacts on biodiversity include national data on number of species extinct and the number of species threatened and data on world heritage sites in danger. The different species covered are amphibians, birds, fish, mammals, plant, reptile tree and vascular plant species over the period 1980-1999. The third edition of Global Biodiversity Outlook (GBO-3)

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<sup>9</sup> GLASID is part of the Land Degradation Assessment at Global Level (LADA) project.

produced by the Convention on Biological Diversity (CBD) summarizes the latest data on status and trends of biodiversity and draws conclusions for the CBD's future strategy. The World Resources Institute (WRI) also reports data on global trade in species and wildlife which provides an indicator of the threats to biodiversity.

**Gender.** An important dimension of monitoring regards indicators that look at impacts on people as a proxy for environmental stresses. The gender disaggregation of indicators can be particularly insightful. Sex-disaggregated indicators are available for health (water and indoor air quality), representation in public office, land ownership and capacity building activities for environmental institutions and processes.

#### **b. Assessing the monitoring gap**

With this scan of data sources in mind, how well prepared is the development community to monitor progress in reducing environmental and natural resource degradation? The main areas of concern identified in this analysis are briefly highlighted below.

Table 5 below summarizes.

- *Indoor air pollution:* Few initiatives exist at the local level to measure dose-response functions and impacts.
- *Urban air pollution:* The analysis showed that there is limited data on air quality and its impacts at the sub-national level. Extrapolation to the country level is often based on models, and country level results vary in quality depending on the availability of monitoring sites in the country. Data on pollution should be complemented by indicators attributable to specific pollution exposures and disaggregated by sex.
- *Water quality:* There is limited comparable data on water quality at the regional/sub-national levels.
- *Land and soil degradation:* Initiatives to monitor land degradation are often unsatisfactory and limited in time<sup>10</sup>.
- *Land ownership:* information on sex disaggregation is very scarce.
- *Forests:* The review showed that there is limited data on degradation of forests.
- *Biodiversity:* There are no databases that record the overall health of ecosystems or that assess the value different ecosystems have for human well being and for production. Fishery health indicators, such as the Marine Trophic Index (Pauly, D. and R. Watson. 2005) are limited in time availability.

A lesson from the review is that monitoring of environmental issues is inadequate given the issues the world faces today. International organizations are not exempt from this problem. In its 2009 review on efforts to achieve sustainable development, the World Bank concluded that “the main challenge to evaluation of environmental results at the project level is the absence of a system across sectors to take stock of, aggregate, and assess progress in achieving environmental outcomes. This is less problematic for projects directly under the management of the environment sector, but is a serious shortcoming for the three-quarters of projects with environmental components that fall under the management of other sectors.”

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<sup>10</sup> At the time of writing, the FAO-led GLASID project promises to be an important source of information.

**Table 5: Quality of indicators for monitoring environmental challenges**

Challenge	Indicator	Quality or gap
Indoor air pollution	PM	Not systematic
Urban air pollution	PM concentrations	Depends on location
	Ground level ozone concentrations	Depends on location
	Other pollutants	Depends on location
Water pollution	Water quality indicator produced from 5 primary indicators	While comparable across countries it does not provide detail of specific areas
Water scarcity	Indicators on water scarcity (water stress, water balance) are in FAO's AQUASTAT.	Fair
Land degradation	GIS based indicators and expert opinion	Poor, limited in time
Deforestation	FAO dataset	Limited data on forest degradation
Climate change	Emissions of various GHGs	Fair
	Concentrations of various GHGs	Fair
	Impacts of climate change	Poor
	Exposure to damages	Fair
	Adaptive capacity	Poor
	Biodiversity	Number of species threatened
Biodiversity	Ecosystem health	Poor
	Value of ecosystem services	Poor
	Protected area coverage	Fair
	Protected area effectiveness	Poor
	Ocean acidification	Ph level of oceans
Ocean acidification	Impact on marine ecosystem	Poor

## 4. Pushing the envelope on environmental monitoring

The previous section showed that major gaps in environmental monitoring include those linked to the health of ecosystems such as soil degradation, forest degradation, the effectiveness of protected areas and the impact of ocean acidification on marine ecosystems. A second group of monitoring gaps relates to the impact that pollution has on men's and women's health, particularly in the case of air and water pollution, and on the economy overall as well as households with different levels of resource access, especially when it comes to vulnerability to, and resilience for adapting to natural resource shocks. This section looks at four areas of engagement that could potentially provide a breakthrough in the way environmental monitoring is done and used. We discuss them in turn.

### a. The use of information and communication technologies (ICT) in environmental monitoring

ICTs are playing a key and rising role environmental management and monitoring. ICTs emit about 2-2.5 percent Greenhouse Gas (GHG), but their estimated positive impact on other sectors – enabling energy efficiencies – will outweigh the adverse effects by five times by the year 2020.

ICTs such as remote sensors, satellite imagery and networks, fiber networks, modeling software, geo-referencing, and online services and Web 2.0 are enabling and expediting not only environmental monitoring, but also analysis, planning, management and protection, mitigation and capacity building. ICTs also enable information sharing, visualization and dissemination like never before.

The International Telecommunication Union (ITU, 2008) has identified six main applications of ICTs in the area of environment: observation, analysis, planning, management and protection, mitigation and capacity building. Further, the ITU is advancing the concept of e-Environment<sup>11</sup> and the United Nations Environment Programme (UNEP) provides several online platforms for sharing resources with environment stakeholders. Specific utilization of ICTs for environmental monitoring include, but are not limited to terrestrial, ocean, climate and atmospheric monitoring, data recording and geographic information systems (GIS). ICTs could also be used for collaboration as well as information sharing and dissemination.

Global, regional and local ICTs systems are set up to collect information, receive early warning, and share environmental information. In response to calls for action by the 2002 World Summit on Sustainable Development and also the G8, the Group on Earth Observations (GEO) oversees building Global Earth Observation System of Systems (GEOSS)<sup>12</sup> to provide information from the observation of the earth to support decision and policy making. The areas of observation include disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.<sup>13</sup>

### **Overcoming technology constraints in developing countries**

The developing countries face a number of challenges in using ICTs for environmental monitoring and sustainability. They are particularly confronted with limited infrastructure, low institutional capacity, low capacity to integrate scientific data into decision and policy making, and limited capacity to implement policy recommendations<sup>14</sup>. These are key areas where these countries need assistance from the developed countries. The Distant Early Warning System (DEWS)<sup>15</sup> sponsored by the German government and others, and the US Indian Ocean Tsunami Warning System (IOTWS)<sup>16</sup> sponsored by the US government, are examples of assistances provided by and ICTs systems put in place, with support from developed countries in the wake of the 2004 Tsunami.

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<sup>11</sup> e-Environment is a term was adopted in the action plan of the 2003 World Summit on Information Society, sponsored by the International Telecommunication Union (ITU), to encompass the use and promotion of ICTs as an instrument for environmental protection and sustainable use of natural resources; sustainable production and consumption and the environmentally safe disposal and recycling of discarded hardware and components used in ICTs; and establishment of monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters.

<sup>12</sup> See <http://earthobservations.org>

<sup>13</sup> [http://www.earthobservations.org/about\\_geo.shtml](http://www.earthobservations.org/about_geo.shtml)

<sup>14</sup> [http://www.itu.int/ITU-D/cyb/app/docs/The\\_Use\\_of\\_ICTs\\_for\\_Environmental\\_Monitoring.pdf](http://www.itu.int/ITU-D/cyb/app/docs/The_Use_of_ICTs_for_Environmental_Monitoring.pdf)

<sup>15</sup> [http://www.dews-online.org/front\\_content.php](http://www.dews-online.org/front_content.php)

<sup>16</sup> [http://usaid.eco-asia.org/files/fact\\_sheets/IOTWS.pdf](http://usaid.eco-asia.org/files/fact_sheets/IOTWS.pdf)

Particularly constraining in developing countries is the capacity to develop, acquire and/or launch satellite-based remote sensing systems. Until recently, this has been usually limited to industrialized countries. However, according to the World Meteorological Organization (WMO), several countries, including Argentina, China, India, Indonesia, Mexico and Thailand, have implemented satellite-based multi-point telecommunication systems for their national Meteorological Telecommunication Networks.

Some of the crucial issues to address for making progress include:

- Scaling up the use of new web-based technologies such as Web 2.0 and service-oriented architecture, which allow more ready access to global data sets.
- Adopting open standards to ensure interoperability. Data that has been organized and stored in servers around the world should not only be linked via the Internet, but it should also be possible to use it without having to deal with software, coding and other format incompatibilities or restrictions. The Global Earth Observation System of Systems (GEOSS) concept as well as other clearinghouse projects are addressing these issues and rely on international standards to ensure interoperability.
- Investing in high speed access to the Internet which will help countries to get access and contribute information as well.
- Making use of battery operated data collection devices that can transmit information using either wireless or satellite transmissions are becoming more widespread and economical. Under some conditions, these technologies may make possible local data collection independent of the availability of broadband connections or reliable power sources.
- Foster south-south cooperation, which would allow transferring knowledge in remote sensing from middle income developing countries to low income developing countries or regions.

The GEOSS initiative allows the use of open source software and GEOSS servers can be run on inexpensive PCs. In this regard, GEOSS takes into consideration the information needs and circumstances and therefore challenges that many developing countries face in accessing data sets for sustainable development. Some of the most important challenges that these countries will have to overcome in order to take full advantage of GEOSS include raising the awareness of key decision-makers in developing countries of the advantages of GEOSS and capacity building, and persuading decision-makers in developing countries to set aside resources to use these resources and make them available as part of e-Government initiatives in the developing world. This will help developing countries in making the information available through GEOSS and like initiatives and resources useful for decision-makers and for use in the development planning process.

## **b. The role of the private sector in environmental monitoring**

The private sector is a stakeholder in the environment and therefore has a role to play in environmental monitoring. While more businesses realize cost-saving or profit-making opportunities in reducing emissions and adopting greener business models, it is yet to be established if the private sector has strong enough incentives in using standards and ICTs for environmental monitoring.

Private sector companies enable environmental monitoring and dissemination of information through invention and innovation of new technologies that facilitate the collection, analysis, sharing, visualization and dissemination of information. There are examples of partnerships between the private sector and environmental organizations – e.g. NASA and Cisco, UNEP and Google – for sharing information. However, the private sector is not a leader in the environmental agenda, rather it responds to pressure and standards from governments, environmental organizations and lenders.

Private sector companies are using modern communication tools to collect and publish environmental data and reports related to their operations, albeit mostly about emissions and efficiency gains. On its website, Shell reports that GHG emissions were reduced by 35 percent between 1990 and 2009.<sup>17</sup> British Petroleum (BP) used ICTs not only to monitor the spill of oil into the Gulf of Mexico, but also uses online resources to disseminate information through its website, Twitter, Facebook, and YouTube.<sup>18</sup> But reporting by the private sector does not follow a standard format and the contents of the reports are not verified by independent parties. A World Bank Report (2010, p 6) refers to ICT companies making “unsubstantiated claims on their green credentials as part of their marketing literature rather than commitment to verifying them.” The report also states that “there is a lack of independent research. Most of the studies to date are carried out, or paid for, by the corporate social responsibility department of ICT companies that have an incentive to put the industry in best light possible.”

To overcome the challenges above, the Global Reporting Initiative (GRI) is an effort to produce a universal standard for sustainability reporting by corporations.<sup>19</sup> Version three of their guidelines and framework has an extensive list of environmental indicators that corporations are requested to include in their sustainability reports. A number of corporations – such as Royal Dutch Shell, Dell, American Electric Power, Hydro-Quebec, Endesa Chile, Hongkong & Shanghai Hotels, Telecom Italia and others – have already adopted the indicators in their annual sustainability reports, which have been reviewed and rated by external committees.

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<sup>17</sup> [http://www.shell.com/home/content/environment\\_society/environment/climate\\_change/managing\\_emissions/managing\\_emissions.html](http://www.shell.com/home/content/environment_society/environment/climate_change/managing_emissions/managing_emissions.html)

<sup>18</sup> <http://www.bp.com>, <http://www.facebook.com/BPAmerica>, <http://www.youtube.com/bp>

<sup>19</sup> <http://www.globalreporting.org> – Global Reporting Initiative (GRI), started in 1997, “is a network-based organization that has pioneered the development of the world’s most widely used sustainability reporting framework and is committed to its continuous improvement and application worldwide. In order to ensure the highest degree of technical quality, credibility, and relevance, the reporting framework is developed through a consensus-seeking process with participants drawn globally from business, civil society, labor, and professional institutions.” Their website features sustainability reports, incorporating GRI indicators, from 53 corporations.

Data collection by the private sector can be utilized for improved policy-making<sup>20</sup>. Such information could be geo-referenced and mashed-up with other data to provide a picture of aggregated environmental impacts. The World Bank could possibly pilot this with IFC and MIGA first and serve as an example for the Equator Principles group. A rewarding mechanism could be used for voluntary sharing into the joint system, which may attract others through network effects.

### **IFC and environmental monitoring**

In general, the IFC<sup>21</sup> has two main avenues to influence the private sector: investment and advisory services, each with a subset of tools. IFC utilizes both avenues for addressing climate change and advancing environmental and social sustainability. IFC's investments and advisory services are governed by its 2006 Policy on Social and Environmental Sustainability, which consists of eight areas of Performance Standards, currently under review through January 2011 (IFC, 2010, p IV). The Multilateral Investment Guarantee Agency (MIGA) also adopted and applies these standards on its clients. Investment is the main area where IFC has direct leverage to enforce its Performance Standards on its clients. The standards set benchmarks for the clients to meet.

IFC receives environmental information, entailed by the standards, from the clients through Annual Monitoring Reports (AMR). The AMRs do not have a specific format; however there is core quantitative information in the standards, varying by type of business, reported by the clients. IFC uses Development Outcome Tracking System (DOTS), which includes a set of 25 environmental indicators (see Annex 2), to track compliance, aggregate the information and report results. At the moment, the information is for internal IFC use and only annual aggregates of compliance and noncompliance are reported publically.

The IFC is leading in setting the environmental standards for its clientele, and other financial institutions adopt and apply them as part of the Equator Principles. IFC (2010) has joined forces with GRI to encourage the private sector to report on their environmental, social and governance performance. They have identified overlapping and non-overlapping areas in their frameworks and indicators. IFC can push the envelope by using ICTs for collecting the information from the clients, share the information internally and externally, and push the environmental agenda from the perspective of the private sector further beyond sustainability of their operations.

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<sup>20</sup> The challenge of promoting information sharing can be tackled by providing incentives to transparency. Sharing the information and making it public increases the transparency of the investors in similar ways to what they request their clients to do.

<sup>21</sup> As part of the World Bank Group, IFC fosters sustainable economic growth in developing countries by financing private sector investment, mobilizing capital in the international financial markets, and providing advisory services to businesses and governments.

### **c. Engaging governments in priority setting and environmental accounting**

The need for monitoring environmental sustainability goes beyond environmental policy, as it involves economic decisions at the country level. In fact, environmental sustainability is closely linked to the sustainability of the whole economy. This is particularly so in developing countries, where nature accounts for a very large portion of assets. For example, in low income countries natural resource account for 36 percent of total wealth, in lower middle income countries the share is 25 percent, and in upper middle income countries it is 17 percent. In high income countries natural capital only accounts for two percent of total wealth (World Bank 2011 (forthcoming)).

Economic decision-making is typically focused on the growth of GDP, but economists have long understood the limitations of the System of National Accounts (SNA) when it comes to the measurement of wellbeing and social welfare. Almost since the inception of the SNA there has been a body of work aimed at increasing the scope and welfare-orientation of the accounts. Among the first attempts to improve welfare accounting, the 'Total Income System of Accounts' (TISA) imputes non-market production, including that in households, re-defines government expenditures on police and defense as intermediate consumption (as well as commuting and other costs associated with work), and expands measures of investment to include R&D, education and health. The first attempt to include adjustments for changes in the environment and natural resources dates back to the Measure of Economic Welfare of Nordhaus and Tobin (1973). Since then, a lot of work has been done and the literature of wealth accounting has expanded rapidly.

Comprehensive frameworks for environmental accounting, and in particular wealth accounting, are rapidly being used by national government agencies, international organizations, and by the UN bodies such as the Statistical Commission. The most comprehensive example of wealth accounting is the one of Norway, which was also the first country to introduce environmental accounting on a regular basis as part of their official statistics in the late 1970s. Other countries, however, have introduced limited asset accounts for select natural resources, most often only for minerals and energy resources, such as oil and natural gas (World Bank 2011, forthcoming).

A number of developing countries, such as Brazil, China, India and Mexico, have developed over the recent years environmental accounting programs. Assets covered by the accounts include sub-soil resources, timber and land. The assets featured most prominently and most regularly are non renewable such as oil, natural gas, coal and minerals. Indonesia and Mexico are among the countries that have regular sub-soil asset accounts. Mexico also compiles regular accounts for timber assets. The United Nations Statistical Commission decided to elevate the Handbook of National Accounting: Integrated Environmental and Economic Accounting (SEEA) to an

international statistical standard<sup>22</sup>. This will put environmental accounting on the same footing as the System of National Accounts. A statistical standard requires a high degree of international agreement on methodology; while there is such agreement for parts of the environmental accounts, there are some aspects of the accounts for which consensus has not yet been reached.

The Stiglitz-Sen-Fitoussi Report,<sup>23</sup> which proposed ways to modify and extend conventional national accounts in order to provide a more accurate and useful guide for policy, endorsed the comprehensive wealth approach to development and the compilation of accounts for certain categories of capital<sup>24</sup>.

The adoption of wealth accounting by national governments is necessary for long-term institutionalization of the accounts. Despite the successful experiences in some countries, and the attention being given to it in international fora, wealth accounting is still far from widespread. Some programs have been suspended partly because of the lack of resources and/or capacity. Data constraints are also a limiting factor.

One area in which the practice of wealth accounting could be substantially improved is the collection of information on cost of extraction of non-renewable resources. As noticed earlier, sub-soil assets account for a very large portion of wealth in many developing countries. But measures of unit rents are estimated only roughly. Correctly estimating extraction costs is essential in estimating the value of the asset and its changes over time. For this to happen, collaboration between statistical agencies, governments and private sector is essential in this respect.

Another area in which theoretical and empirical research could contribute substantially is the estimation of ecosystem benefits. Available estimates of wealth and its changes rarely include the value of ecosystems. When estimated, such values are often measured in a conservative way<sup>25</sup>. Ecosystems are essential for production and to sustain human health so they underpin a potentially large portion of a country's wealth. The relevant question, of how important ecosystems are in economic terms, remains largely unanswered and is a major limitation to natural resource policy making in most of the developed and developing world.

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<sup>22</sup> Also worth mentioning, is that the United Nations Statistical Commission, at its 41st Session (23-26 February 2010), endorsed a program of work for the revision of the UN Framework for the Development of Environment Statistics (FDES). The UN Statistical Commission recommended that an Expert Group be established to conduct the revision of the FDES and that all relevant stakeholders be engaged in the process. The Statistical Commission further provided a set of guiding principles for the program of work.

<sup>23</sup> Report by the Commission on the Measurement of Economic Performance and Social Progress, 2009

<sup>24</sup> The report takes a conservative position on the possibility of accurately valuing some types of natural capital. Their recommendations are discussed later in this chapter.

<sup>25</sup> In World Bank 2011 (forthcoming) for example, the value of protected areas is estimated as the opportunity cost of non using the land under protection for crop or pasture production, whichever is lower.

#### **d. Linking project level and country level monitoring**

Another step in the direction of improving monitoring efforts is to strengthen the capacity to collect standardized environmental information at the project level. The term “standardization” is crucial as it implies the possibility of aggregating results at a scale that goes beyond the individual project and that can be tracked at the national level.

World Bank management is working to establish a “results monitoring platform” to strengthen monitoring and reporting on the outcomes of Bank- supported activities. One key step is the adoption of core sector indicators— a few standardized indicators for each sector that are comparable and that can be aggregated at the institutional, country, or sector level, which will facilitate reporting on activity outputs and outcomes. A specific application is given by the IDA Results Measurement System (IDA RMS). While core indicators for the road transport, water supply, education, and health sectors were launched in July 2009, together with an improved data system for collecting and tracking quantitative data, indicators for the environment theme have are still under preparation, together with core indicators for other sectors (urban, micro, small, and medium enterprises, and so on). These indicators (mainly output and outcome indicators appropriate for tracking at the project level), together with the country- or sector- level indicators available from other sources, should improve the international community’s ability to focus on results. In addition, setting up a results platform would offer practitioners tools for monitoring country portfolio results and for making more strategic and effective use of impact evaluations where these are appropriate.

Taking the above into account, the new World Bank Group (WBG) Environment Strategy should work towards a robust results framework with the following characteristics: (i) be monitorable; (ii) be comprehensive; and (iii) ensure operational ownership. For the results framework to be monitorable, it needs to clearly identify outputs and results indicators and define who will report and be hold accountable for outputs and result indicators. Comprehensiveness comes with a natural tension between applicability of the strategy across the WBG and relevance of the strategy for the different branches that make up of the WBG (IDA, IBRD, IFC, MIGA) and the individual regions. The organization can however capitalize on the work done over the years by its research department, the environment anchor and operational departments and use staff and data resources effectively to overcome these challenges.

### **5. Summing up**

The world faces unprecedented challenges over the coming decades. This paper reviews the major environmental and natural resource issues at the global level. It then identifies the relevant data and indicator sets available at the global level and country level to capture the global and locally relevant environmental issues with the underlying objective of informing and advising decision making and to identify the data gaps. The environmental issues reviewed include air pollution and deterioration of air quality, greenhouse gas emissions and climate change, water

quality, scarcity and access to improved water, land and soil degradation, deforestation and forest degradation, natural disaster, loss of biodiversity and protected areas, and environmental governance and institutions for environmental and natural resource management.

Among the most pressing issues, this paper identified the threats from climate change caused by GHG emissions, biodiversity loss, water pollution and scarcity, pressure on land, and the worsening state of oceans. Many hard won gains from long term development efforts may be lost in a very short time owing to irreversibility and the passing of critical thresholds. It is in this context that environmental sustainability becomes a key element of policy making, and monitoring is a key tool.

The paper reviewed and traced the suite of available indicators to identify data availability, gaps and possible opportunities for augmenting indicator sets for use in country operations and environmental economic work. The analysis shows three type of gaps:

- Discontinuity in space – Urban and indoor air pollution, the measurement of the impacts of urban and indoor air pollution does not take place in a systematic way across the world. Monitoring stations for urban air pollution are located in major cities but the quality of the data collected varies widely across countries. Information on indoor air pollution is limited to very specific locations and is not always sex-disaggregated. The impacts on human health are also rarely measured and such initiatives, typically led by research centers, are site specific. Similar considerations can be made for water quality and its effects on health.
- Discontinuity in time – Land quality and land degradation has taken place irregularly over time. The latest comprehensive attempt dates back to 1990. The works of different international agencies like FAO, GEF, World Bank, and UNEP could be coordinated to development of more comprehensive database on indicators of land and soil degradation. Although data on land degradation are currently limited, there are some initiatives at the global level to assess the extent and causes of land degradation. Land quality and land degradation changes should also be linked to changes in land ownership; land ownership data should be tracked by sex.
- Almost absent monitoring – The quality of ecosystem services and the state of the world's oceans has traditionally escaped the monitoring efforts of countries and international organizations. The relevance of these assets to women's and men's lives and to economic production are little understood.

Moving forward, the paper has identified four areas in which action could be taken in the short term to improve the monitoring of environmental and natural resource issues. Overcoming the digital divide in developing countries is essential to harness the potential of ICTs for environmental monitoring. This goes from the use of readily available mapping tools, the use of Web2.0 platforms and the use of battery operated devices to transfer information quickly from coordinating agencies to users and vice versa. The private sector is in a privileged position to monitor the environmental sustainability of economic production and to take action on it.

Building partnerships involving the private sector in monitoring, providing incentives and designing standards for environmental monitoring and management are all part of the agenda forward. The private sector also holds information that can be exploited to measure the economic value of commodities such as timber, energy resources and mineral resources. This in turn is crucial to feed a wealth accounting framework which could be in itself a major user of environmental information and a very useful tool for decision making. Finally, international organizations like the World Bank have a crucial role to play in linking project level and country level indicators through a consistent monitoring system that can aggregate information at the project level up to a scale that reaches country relevance.

## 6. Recommendations for the 2010 Environment Strategy

From a World Bank institutional perspective, there is work to be done in the WBG approach to support to countries in their monitoring efforts for sustainability. A recent review by the Bank's Independent Evaluation Group (IEG) identified a 'mixed record on implementing the agenda to strengthen... monitoring of development results'. While the World Bank has moved to strengthen monitoring of its programs and projects, including the introduction of the IDA Results Measurement System, in many instances information is not sufficiently rigorous or comprehensive to provide clients and other stakeholders with an adequately detailed and objective account of the results achieved by World Bank actions.

To make progress on the environmental monitoring agenda drawing from the paper's findings, it is recommended that the WBG:

- **Develop a core set of indicators for environmental sustainability.** The core set of indicators would be a key element of results frameworks in WBG strategies and projects. It would allow for systematic tracking of a number of key issues across the institution's portfolio and progressive improvement of the mapping between actions and results on the ground.
- **Establish an analytic and advisory activity (AAA) program on ecosystem valuation and wealth accounting.** Such a program would increase WB's capacity to advise clients on sustainability effects of environmental interventions, and support clients with a tool to measure effectiveness in increasing their asset base.
- **Develop a list of core indicators on environmental governance building on the Country Policy and Institutional Assessment (CPIA) system.** This would strengthen the Bank's ability to assess clients' policy and institutional performance on environmental management.
- **Promote private sector use of ICTs for monitoring environmental impacts and reporting the information to IFC and stakeholders.** The IFC is taking the lead in setting environmental standards for its clients, standards which other financial institutions adopt and apply as part of the Equator Principles. IFC has joined forces with the Global Reporting Initiative (GRI) to

encourage the private sector to report on their environmental, social and governance performance. They have identified overlapping and non-overlapping areas in their frameworks and indicators. However, the Road Test Version of the IFC-GRI publication about the joint effort does not address a role for ICTs.

- **Coordinate with different international agencies like FAO, GEF and UNEP to develop more comprehensive databases on indicators of land and soil degradation.** Such a coordinated effort could improve land and social degradation monitoring, as current initiatives to monitor land degradation are often unsatisfactory and limited in time.

## References

- Bai Z.G., Dent D.L., Olsson L. and Schaepman M.E. .2008. "Global assessment of land degradation and improvement. 1. Identification by remote sensing". Report 2008/01, ISRIC – World Soil Information, Wageningen
- Campbell-Lendrum, D. H., C. F. Corvalan, and A. Pruss-Ustun. 2003. "How Much Disease Could Climate Change Cause?" In *Climate Change and Human Health: Risks and Responses*, ed. A. J. McMichael, D. H. Campbell-Lendrum, C. F. Corvalan, K. L. Ebi, A. Githeko, J. D. Scheraga, and A. Woodward. Geneva: World Health Organization.
- CBD 2010. *Global Biodiversity Outlook 3*. Montréal: Secretariat of the Convention on Biological Diversity.
- Chomitz, M. Kenneth, Piet Buys, Giacomo De Luca, Timothy S. Thomas, and Sheila Wertz-Kanounnikoff. 2006. *At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests*. Policy Research Report. Washington, DC: World Bank
- Cline, W. R. 2007. "Global Warming and Agriculture: Impact Estimates by Country". Washington, DC: Center for Global Development and Peterson Institute for International Economics.
- Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn and H. Savelli (eds). 2010. "2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment". United Nations Environment Programme, UN-HABITAT, Nairobi, Kenya.
- Dell, M., B. F. Jones, and B. A. Olken. 2008. "Climate Change and Economic Growth: Evidence from the Last Half Century." Working Paper 14132, National Bureau of Economic Research, Cambridge, MA.
- Dentener F., D. Stevenson, J. Cofala, R. Mechler, M. Amann, P. Bergamaschi, F. Raes, and R. Derwent. 2005. "The Impact of Air Pollutant and Methane Emission Controls on Tropospheric
- FAO. 2004. "The State of Food and Agriculture 2009". Food and Agriculture Organization of the United Nations, Rome, 2004.
- FAO. 2005. *Global Forest Resource Assessment 2005*. <http://www.fao.org/forestry/site/fra/en>
- FAO. 2009. "The State of Food and Agriculture 2009". Food and Agriculture Organization of the United Nations, Rome, 2009.
- FAO. 2009a. "1.02 Billion People Hungry". Food and Agriculture Organization of the United Nations, Rome. <http://www.fao.org/news/story/en/item/20568/icode> (retrieved 29.3.2010)
- FAO. 2009b. "State of World's Forests". Food and Agriculture Organization of the United Nations, Rome, 2009.
- FAO. 2009c. "Review of evidence on drylands pastoral systems and climate change. Implications and opportunities for mitigation and adaptation". Land and Water Discussion Paper 8, Food and Agriculture Organization of the United Nations, Rome, 2009.
- FAO. 2010. "Fisheries and Aquaculture in our Changing Climate". Brochure. Food and Agriculture Organization of the United Nations, Rome. [ftp://ftp.fao.org/FI/brochure/climate\\_change/policy\\_brief.pdf](ftp://ftp.fao.org/FI/brochure/climate_change/policy_brief.pdf) (retrieved 29.3.2010)
- Gouveia, C., A. Fonseca (2008). New approaches to environmental monitoring: the use of ICT to explore volunteered geographic information. *GeoJournal* (2008) 72:185–197.

- Hanson, T., Brooks, T.M., da Fonseca, G.A.B., Hoffmann, M., Lamoreux, J.F., Machlis, G., Mittermeier, C.G., Mittermeier, R.A. and Pilgrim, J.D. (2009). Warfare in Biodiversity Hotspots. *Conservation Biology*, 23(3), 578-587.
- Hart, J.K., K. Martinez (2006). Environmental Sensor Networks: A revolution in the earth system science?, *Earth-Science Reviews*, 78, pp. 177-191.
- HIIK (2009). Conflict Barometer 2009. Heidelberg Institute for International Conflict Research, Heidelberg.
- IEA. 2006. "World Energy Outlook 2006". International Energy Agency, Paris.
- IEA. 2009. "World Energy Outlook 2009". International Energy Agency, Paris.
- IFPRI. 2008. "High food prices: the what, who, and how of proposed policy actions". Policy Brief, May 2008. International Food Policy Research Institute, Washington, DC.
- IFPRI. 2009. "Climate Change. Impact on Agriculture and Costs of Adaptation". Food Policy Report. International Food Policy Research Institute, Washington, DC, 2009.
- IMF (International Monetary Fund). 2003. "Being Prepared: Natural Disasters Are Becoming More Frequent, More Destructive, and Deadlier, and Poor Countries Are Being Hit the Hardest," by Paul K. Freeman, Michael Keen, and Muthukumara Mani. *Finance and Development* 40 (3):42-45.
- International Federation of Red Cross and Red Crescent Societies. 2005. *World Disasters Report 2005: Focus on information in disasters*. Geneva: International Red Cross.
- IPCC. 2007. "Climate Change 2007 – The Physical Science Basis". Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- IPCC. 2007a. "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change". Geneva: IPCC.
- ISDR. 2009. "Global Assessment Report on Disaster Risk Reduction: Risk and poverty in a changing climate". United Nations International Strategy for Disaster Reduction, Geneva.
- ITU (2008). *ICTs for e-Environment: Guidelines for developing countries, with a focus on climate change*, ITU, Geneva.
- IUCN. 2009. "Extinction crisis continues apace. International Union for Conservation of Nature".  
[http://www.iucn.org/about/work/programmes/species/red\\_list/?4143/Extinction-crisis-continues-apace](http://www.iucn.org/about/work/programmes/species/red_list/?4143/Extinction-crisis-continues-apace)  
 (retrieved 5. 4. 2010).
- IWMI. 2007. "Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute.
- Karl, T. R., J. M. Melillo, and T. C. Peterson. 2009. "Global Climate Change Impacts in the United States". Washington, DC: U.S. Climate Change Science Program and the Subcommittee on Global Change Research.
- Labelle, Richard, *ICT Linkages to Climate Change – Trends and Potential Interventions*, World Bank (CITPO), Ver.1.03. Final Report.
- MA. 2005. "Millennium Ecosystem Assessment Ecosystems and Human Well-being: Current State and Trends, Volume 1". Island Press: Washington, Covelo, London.
- MDG. 2009. "The Millennium Development Goals Report 2009". United Nations, New York.

Müller, C., A. Bondeau, A. Popp, K. Waha, and M. Fader. 2009. "Climate Change Impacts on Agricultural Yields." Background note for the WDR2010.

Nachtergaele Freddy O., Monica Petri, Riccardo Biancalani, Godert van Lynden and Harrij van Velthuizen 2010. Global Land Degradation Information System (GLADIS) Beta Version: An Information database for Land Degradation Assessment at Global Level. LADA Technical report n. 17

Nordhaus, W., and J. Tobin. 1973. Is Growth Obsolete? In Moss (ed), 1973.

OECD 2009. Conference proceedings: ICTs, the Environment and Climate Change. Proceedings of the high-level OECD Conference in Helsingør, Denmark, 27-28 May 2009. Retrieved from: <http://www.oecd.org/dataoecd/49/59/44149232.pdf> (10. July 2010).

OECD. 2008. "OECD Environmental Outlook to 2030". Organisation for Economic Co-Operation and Development, Paris, 2008.

OECD. 2008a. "Natural Resources and Pro-Poor Growth, The Economics and Politics". DAC Guidelines and Reference Series. Organisation for Economic Co-Operation and Development, Paris, 2008.

Ozone and Radiative Forcing: CTM calculations for the Period 1990-2030", *Atmos. Chem. Phys.*, 5, 1731-1755.

Pauly, D. and R. Watson. 2005. Background and interpretation of the 'Marine Trophic Index' as a measure of biodiversity. *Philosophical Transactions of the Royal Society: Biological Sciences* 360: 415-423.

Pica, G., Pica-Ciamarra, U. & Otte, J. 2008. "The livestock sector in the World Development Report 2008: re-assessing the policy priorities". PPLPI Research Report No. 08-07. Rome, Pro-Poor Livestock Policy Initiative, FAO.

Rockström, J., Steffen, W., Noone, K., Person, Å., Chapin III, S.F., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., Wit, C.A., Hughes, T., Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Wlaker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J.A. 2009. "Planetary Boundaries: Exploring the safe operating space for humanity". *Ecology and Society*, 14, 2.

Sitglitz, J., Sen, A., Fitoussi, J., Report by the Commission on the Measurement of Economic Performance and Social Progress, 2009.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V, Rosales, M., and de Haan, C. 2006. "Livestock's long shadow. Environmental issues and options". Rome, FAO.

UNCCD. 2009. "Benefits of Sustainable Land Management". Bonn: United Nations Convention to Combat Desertification.

UNDP. 2008. "Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World". New York: UNDP.

UNEP. 1999. Global Environmental Outlook. Nairobi, Kenya: Division of Environmental Information, Assessment and Early Warning, United Nations Environment Program.

UNEP. 2007. "Global Environment Outlook, GEO4, Environment for development". United Nations Environment Programme, Nairobi, Kenya.

UNEP. 2008. "Vital Water Graphics, An Overview of the State of the World's Fresh and Marine Waters". 2nd Edition (2008). <http://www.grida.no/publications/vg/water2> (28.3.2010).

UNEP. 2009. "Black Carbon e-Bulletin". Volume 1, Number 2, September 2009.

- UNEP. 2010. "UNEP Year Book. New Science and Development in our Changing Environment. 2010". United Nations Environment Programme, Nairobi, Kenya.
- UNICEF and WHO. 2003. "Meeting the MDG Drinking Water and Sanitation Target." <http://www.unicef.org/wes/mdgreport/sanitation0.php>
- WHO. 2002. "Addressing the links between indoor air pollution, household energy and human health." Based on the WHO-USAID global consultation on the health impact of indoor air pollution and household energy in developing countries (meeting report). Washington, DC: World Health Organization.
- WHO. 2006. "Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide". World Health Organization, Geneva.
- WHO. 2010. "UN-water global annual assessment of sanitation and drinking-water (GLAAS) 2010: targeting resources for better results". World Health Organization, Geneva.
- WHO/UNICEF. 2010. "Progress on sanitation and drinking water, 2010 update." WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.
- World Bank 2004. "Natural Disasters: counting the cost". Feature story on March 2, 2004, World Bank, Washington DC.
- World Bank 2006. "Hazards of Nature, Risks to Development: An IEG Evaluation of World Bank Assistance for Natural Disasters". World Bank, Washington DC.
- World Bank 2006a. "Sustainable Land Management. Challenges, Opportunities and Trade-Offs". World Bank, Washington DC.
- World Bank 2008. "Climate Change: Adaptation and Mitigation in Development Programs: A Practical Guide". World Bank, Washington DC.
- World Bank 2009. "Achieving Sustainable Development: Annual Review of Development Effectiveness 2009". World Bank, Washington DC.
- World Bank 2010. "World Development Report 2010: Development and Climate Change". World Bank, Washington DC.
- World Bank 2010a. "Climate Change beta site". World Bank, Washington DC.  
<http://beta.worldbank.org/content/about-climate-change-site> (retrieved 22.04.2010)
- World Bank 2010b. Little Green Data Book 2010. World Bank, Washington DC.
- World Bank 2010d. ICT Linkages to Climate Change – Potential WBG Interventions.
- World Bank 2011 (forthcoming). The Changing Wealth of Nations: Measuring sustainable development in the new millennium. Washington: The World Bank.
- World Commission on Water. 1999. "Report of the World Commission on Water." International Journal of Water Resources Development 16(3): 289–320.
- WRF. 2010. "The Issue Global resource use - Worldwide patterns of resource extraction". World Resources Forum: St. Gallen, 2010. <http://www.worldresourcesforum.org/issue> (retrieved 25.4.2010).

## **Annex 1: Review of Environmental and Natural Resource Indicators**

The purpose of this section is to present the available indicators on the state of the environment and natural resources at the country and regional/local levels and map these indicators to trace the environmental and natural resources problems identified in the previous section. This section will present the available indicators and data sources. For each of the environmental and natural resources issues, indicators will be identified to represent the problem, causes and impact on well being and/or production.

### **Indicators of air pollution and air quality**

#### *Indicators to measure air pollution and air quality:*

##### a. Indicators of indoor air pollution:

1. *Index of indoor air pollution*: represents air pollution from use of solid fuels such as wood, charcoal, crops and other agricultural waste, dung, shrubs and straw and coal. County wide data are available for 182 countries and the most recent data is for year 2007.

*Source*: World Health Organization- Geneva: Smith K.R., Mehta S. Maeusezahi-Feuz M. 2004. Indoor air pollution from household use of solid fuels. In Comparative quantification of health risks: Global and regional burden of disease attributable to selected major risk factors (Ezzati M., Lopez, A.D., Rodgers, A. Murray, CIL, eds)

[http://www.who.int/quantifying\\_ehimpacts/national/countryprofile/maplap/en/index.html](http://www.who.int/quantifying_ehimpacts/national/countryprofile/maplap/en/index.html)

2. *Indoor Air Pollution and Exposure Database*: Household Measurements in Developing Countries. Community level data on measured household indoor air pollution levels in about 250 communities in developing countries.

*Source*: University of California, Berkley: <http://ehs.sph.berkeley.edu/hem/page.asp?id=33>

3. *Indoor Air Pollution Database in China*: This database has data abstracted from more than 110 published papers with measurements of air quality in Chinese households, mostly from the Chinese literature previous to 1995. It is organized by pollutant (Particulates, Sulfur Dioxide, Carbon Monoxide, Nitrogen Oxides, Benzo[a]pyrene); fuel type (Coal & Mixed, Gas, Biomass); and location (Urban, Rural).

*Source*: University of California, Berkeley: <http://ehs.sph.berkeley.edu/hem/page.asp?id=32>

b. Indicators of outdoor air pollution

1. *Urban air quality*: Measures urban population weighted PM10 levels in residential areas of cities with more than 100,000 residents and is expressed in micro-grams per cubic meter. Data are available for 185 countries and the latest data is for 2007.

Source: World Development Indicators, World Bank: <http://devdata.worldbank.org/dataonline>

2. *Air Quality Index*: The Air Quality Index (AQI), also known as the Air Pollution Index (API) or Pollutant Standard Index (PSI), is an index used by government agencies, mostly in developed countries, to characterize the quality of the air at a given location. AQI by location is available for South Korea, Canada, Hong Kong, Mainland China, Malaysia, Mexico, Singapore, United Kingdom and United States.

Sources:

*South Korea*: The Ministry of Environment is responsible for the Comprehensive AQI and is available at <http://eng.airkorea.or.kr/cai/main.jsp>

*Canada*: The Meteorological Service of Canada (MSC) tracks AQI in major cities and the URL for this database is:

<http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=89B1C598-1>

*Hong Kong*: The Air Pollution Index (API) levels for Hong Kong is related to the measured concentrations of ambient respirable suspended particulate (RSP), sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), ozone (O<sub>3</sub>) and nitrogen dioxide (NO<sub>2</sub>) over a 24-hour period based on the potential health effects of air pollutants. The API is monitored and recorded Environmental Protection Department and the URL is <http://www.epd-asg.gov.hk>

*United States*: The USEPA has developed threshold levels of AQI for different pollutants like sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), suspended particulates (PM<sub>10</sub>), carbon monoxide (CO), and ozone (O<sub>3</sub>) are available at:

[http://www.epa.gov/airnow/aqi\\_tech\\_assistance.pdf](http://www.epa.gov/airnow/aqi_tech_assistance.pdf)

<http://iaspub.epa.gov/enviro/datafinder.html?pType=2&pLevel=2&pItem=1006>

### Indicators to trace the causes of air quality and pollution

Data on the following pollutants are available at the country level:

1. *Carbon Monoxide emissions*: Carbon monoxide (CO) is a precursor gas of ground-level ozone, which can trigger serious respiratory problems. This indicator represents emissions of Nitrogen Oxides (NO<sub>x</sub>) divided by the populated land area at more than five persons per square kilometer expressed in gigagrams per 1000 square kilometer. Data for the years 1990, 1995 and 2000 and updates are available.

2. *Nitrogen Oxide emissions*: This indicator represents emissions of Nitrogen Oxides (NO<sub>x</sub>) divided by the populated land area at more than five persons per square kilometer expressed in gigagrams per 1000 square kilometer. Data for the years 1990, 1995 and 2000 and updates are available.

3. *Non-Methane Volatile Organic Compounds emissions (NMVOC)*: Emissions of NMVOC divided by the populated land area at more than five persons per square kilometer expressed in gigagrams per 1000 square kilometer. Data for the years 1990, 1995 and 2000 and updates are available for 223 countries.

4. *Sulfur dioxide emissions*: Emissions of Sulfur Dioxide (SO<sub>2</sub>) divided by the populated land area at more than five persons per square kilometer expressed in gigagrams per 1000 square kilometer. Data for the years 1990, 1995 and 2000 and updates are available.

*Source*: The primary source for CO, NO<sub>x</sub>, NMVOC and SO<sub>2</sub> emissions is the Emission Database for Global Atmospheric Research (EDGAR) reports. The country level data are also reported by World Resources Institute (WRI) in the Earthtrends database:

<http://www.mnp.nl/edgar>

<http://earthtrends.wri.org/searchabledb/index.php?>

The EDGAR database also includes country-level totals for individual emissions by source types, where available. Data used in EDGAR database are compiled from the best possible international data sources; however it is stressed that the uncertainties in the resulting datasets may be substantial at the country level.

### **Indicators of impact or outcome of air quality**

Impacts of air quality are mostly on health and the possible indicators to track such are presented below:

1. *Total mortality*: Total mortality is the most commonly collected and used parameter of population health and is relatively consistently and readily available and comparable across countries. It is the probability of dying between 15-60 years per 1000 population. But this data cannot be treated as the direct health effects of air pollution and/or poor air quality as only a fraction of mortality is attributable to it. However, mortality data are necessary for computation of the disease burden attributable to air pollution expressed as Years of Life Lost (YLL). This data is currently maintained in sex-disaggregated form.

*Source*: WHO Statistical Information System (WHOSIS) provides mortality data for 194 countries for both sexes and is available online at: <http://www.who.int/whosis/en/index.html>

2. *Morbidity indicators*: Morbidity indicators will provide more extensive and specific information on burden of air pollution on health. But differences in healthcare systems, diagnosis and reporting may result in problems comparing across countries. (see previous URL).

3. *Indicators that integrate burden of disease attributable to pollution:* Disability Adjusted Years of Life (DALY) is a health gap measure that extends the concept of potential years of life lost (PYLL) to premature death to include equivalent years of healthy life lost by virtue of being in states of poor health or disability. The environmental burden of disease integrates DALYs from poor water, sanitation and hygiene, indoor and urban air pollution, lead exposure and climate change. Another similar indicator is QALY (Quality Adjusted Years of Life). Data on DALYs is available for 192 countries and the latest year for which data is available is 2004.

*Source:* World Health Organization, Geneva- Priuss-Ustun, A. and Corvaian. 2006. Preventing disease through healthy environments: Towards an estimate of the environmental burden of disease:

[http://www.who.int/quantifying\\_ehimpacts/national/countryprofile/intro/en/index.html](http://www.who.int/quantifying_ehimpacts/national/countryprofile/intro/en/index.html)

[http://www.who.int/quantifying\\_ehimpacts/publications/preventingdisease/en/index.html](http://www.who.int/quantifying_ehimpacts/publications/preventingdisease/en/index.html)

4. *Indicators attributable to specific pollution exposures:* Construction of such indicators requires exposure-response relationships as well as data on population exposure and on underlying frequency of analyzed health outcome. These indicators comparable across countries are not readily available but must be modeled.

5. *Indicators relevant to susceptible or vulnerable groups:* Examples of such possible indicators are Post neo-natal mortality due to respiratory diseases, or of groups like asthmatics or children and are disaggregated by sex.

## **Indicators of Green House Gas (GHG) emissions and climate change**

This section present the indicators to assess the climate change, causes of climate change and possible impacts of climate change.

### *Measuring climate change*

Global mean surface temperatures:

1. *Global mean surface temperature:* Measures the average global surface temperature in degrees Centigrade for a given year. NASA GISS Surface Temperature (GISTEMP) data are available from 1880 to the present.

*Source:* Goddard Institute for Space Studies (GISS). 2006. NASA GISS Surface Temperature Analysis (GISTEMP). New York: GISS and is available on-line at:

<http://data.giss.nasa.gov/gistemp>

2. *Global Surface Temperature Anomalies:* Temperature anomaly" means a departure from a reference value or long-term average, a positive anomaly indicates that the observed temperature was warmer than the reference value and vice versa. Data are available from 1880 to the present.

Source: National Oceanic and Atmospheric Administration National Climatic Data Center  
<http://www.ncdc.noaa.gov/cmb-faq/anomalies.html>

3. *IPCC dataset on climate change*: The Intergovernmental Panel on Climate Change maintains the exhaustive database on climate change at: [http://www.ipcc-data.org/ddc\\_about.html](http://www.ipcc-data.org/ddc_about.html)

### **Indicators to measure factors that contribute/causes climate change**

1. *CO2 emissions per capita*: CO2 emissions per capita represents the mass of carbon dioxide (CO2) emitted per person for a country or region, in metric tons. National data are available for 222 countries from 1990 onwards.

Source: International Energy Agency: <http://data.iea.org/ieastore/default.asp> and World Resources Institute: <http://earthtrends.wri.org>

2. *CO2 emissions per GDP*: The quantity of carbon dioxide (CO2) released into the atmosphere for each million dollars of Gross Domestic Product (GDP) in a country or region. Data are in metric tons of CO2 per million constant 2005 United States dollars for the data span 1980-2005.

Source: International Energy Agency: <http://data.iea.org/ieastore/default.asp> and World Resources Institute: <http://earthtrends.wri.org>

3. *CO2 emissions from cement production, thousand metric tons of CO2*: The total mass of carbon dioxide (CO2) emissions produced as cement is calcined to produce calcium oxide. The Carbon Dioxide Information Analysis Center (CDIAC) releases time series CO2 emissions data that extend back to 1751 for some countries, such as the United Kingdom. Data here are for 1900-2006, when available. For most countries, however, time-series emissions data begin at around 1950 and are updated every 18-24 months.

Source: CDIAC and WRI: <http://cdiac.esd.ornl.gov/ftp/ndp030> and at <http://earthtrends.wri.org>

4. *CO2 emissions from gas flaring*: The total mass of carbon dioxide (CO2) emissions produced from the burning of gas released in the process of petroleum extraction, in thousand metric tons of CO2. National data for most countries are from 1950.

Source: CDIAC and WRI: <http://cdiac.esd.ornl.gov/ftp/ndp030> and at <http://earthtrends.wri.org>

5. *CO2 emissions from gas fuels*: The total mass of carbon dioxide (CO2) emissions produced primarily, but not exclusively, from the burning of natural gas but do not include bunker fuels used in international transportation. Data from WRI are reported here in thousand metric tons of CO2 and CDIAC reports in elemental C.

Source: CDIAC and WRI: <http://cdiac.esd.ornl.gov/ftp/ndp030> and at <http://earthtrends.wri.org>

6. *CO2 emissions from liquid fuels*: The total mass of carbon dioxide (CO2) emissions produced primarily, but not exclusively, from the burning of petroleum products, but do not include bunker fuels used in international transportation. Data are reported here in thousand metric tons of CO2 and in most cases from 1950 onwards.

Source: CDIAC and WRI: <http://cdiac.esd.ornl.gov/ftp/ndp030> and at <http://earthtrends.wri.org>

7. *CO2 emissions from solid fuels*: The total mass of carbon dioxide (CO2) emissions produced primarily, but not exclusively, from the burning of coal but does not include bunker fuels used in international transportation. Data are reported here in thousand metric tons of CO2 and in most cases from 1950 onwards.

Source: CDIAC and WRI: <http://cdiac.esd.ornl.gov/ftp/ndp030> and at <http://earthtrends.wri.org>

8. *Cumulative CO2 emissions from land use change*: The total mass of carbon dioxide (CO2) absorbed or emitted into the atmosphere between 1950 and 2000 as a result of man-made land use changes (e.g., deforestation, shifting cultivation, vegetation re-growth on abandoned croplands and pastures).

Source: Climate Analysis Indicators Tool (CAIT) version 3.0. (Washington, DC: World Resources Institute, 2005): <http://cait.wri.org> and <http://earthtrends.wri.org>

9. *Residential carbon dioxide emissions per capita*: An indicator of how much carbon dioxide (CO2) is emitted per person from residential fossil fuel use. "Residential use" includes CO2 released from the burning of all fossil fuels in households such as coal and coal products, oil, and natural gas. Data are reported in kilograms of CO2 per person for selected years from 1990.

Source: International Energy Agency (IEA) Statistics Division. 2006. CO2 Emissions from Fuel Combustion (2006 edition). Paris: IEA: <http://data.iea.org/ieastore/default.asp>

10. *Total carbon dioxide emissions*: Total mass of carbon dioxide (CO2) released from the burning (combustion) of all fossil fuels in a particular country or region reported in million metric tons (tonnes) of carbon dioxide. Fossil fuels include coal and coal products, oil, and natural gas. CO2 emissions from land use change, biomass fuels and cement manufacture are not included here. Data are for selected years from 1990.

Source: International Energy Agency (IEA) Statistics Division. 2006. CO2 Emissions from Fuel Combustion (2006 edition). Paris: IEA: <http://data.iea.org/ieastore/default.asp>

11. *Non-CO2 Greenhouse Gas Emissions*: Fluorinated gases- Measures the total release of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) into the Earth's atmosphere. National data for the year 1990, 1995, 2000 and 2005.

Source: WRI <http://cait.wri.org> WRI calculates fluorinated gas emissions from 2 sources-EPA available at <http://www.epa.gov/nonco2/econ-inv/international.html> and from EDGAR 3.2 by RIVM/TNO available at: <http://www.mnp.nl/edgar/model/edgarv32/ghg>

12. *Non-CO2 Greenhouse Gas Emissions: Methane* measures the total release of methane (CH<sub>4</sub>) into the Earth's atmosphere as a result of human activities. Values are expressed in thousand metric tons of CO<sub>2</sub> equivalent and data are available for the years 1990, 1995, 2000 and 2005.

Source: WRI <http://cait.wri.org> WRI calculates fluorinated gas emissions from 2 sources-EPA available at <http://www.epa.gov/nonco2/econ-inv/international.html> and from EDGAR 3.2 by RIVM/TNO available at: <http://www.mnp.nl/edgar/model/edgarv32/ghg>

13. *Non-CO2 Greenhouse Gas Emissions: Nitrous Oxide* measures the total release of nitrous oxide (N<sub>2</sub>O) into the Earth's atmosphere as a result of human activities. Values are expressed in thousand metric tons of CO<sub>2</sub> and are available for the years 1990, 1995, 2000 and 2005.

Source: WRI <http://cait.wri.org> WRI calculates fluorinated gas emissions from 2 sources-EPA available at <http://www.epa.gov/nonco2/econ-inv/international.html> and from EDGAR 3.2 by RIVM/TNO available at: <http://www.mnp.nl/edgar/model/edgarv32/ghg>

## **Indicators on water resources**

### *Indicators of water quality and scarcity*

#### a. Water quality:

1. *Water Quality Index (WQI)*: WQI is a proximity-to-target composite indicator constructed with raw data for five parameters; dissolved oxygen, electrical conductivity, pH, total phosphorous and total nitrogen (or Nitrate/nitrite/Ammonia). WQI are available at the country level for about 170 countries.

Sources: UNEP, GEMS/Water Program 2008; European Environment Agency  
<http://www.gemswater.org>

2. GEMStat, Waterbase Rivers and Lakes datasets, Center for International Earth Science Information Network (CIESIN) Columbia University. Water quality data for more than 100 countries and over two million entries for lakes, reservoirs, rivers, groundwater systems at the regional/local level: <http://www.gemswater.org>; <http://www.eea.europa.eu/themes/waterdatasets>

#### b. Indicators of quantity and scarcity of water:

1. *Water stress index*: Water Stress Index is the percentage of a country's territory affected by oversubscription of water resources. It is the total fresh water withdrawals (surface, ground, desalinated and wastewater reused) as a percent of total renewable water resources.

Source: University of New Hampshire, Water Systems Analysis Group  
<http://www.watsys.sr.unh.edu>

2. *Water Balance*: A water balance indicator that estimates water balance at the regional watershed level. The water balance is based on renewable water supply, water demand from industrial agricultural and domestic sectors, water surplus and shortfall throughout the continent, and the dependency of watersheds on inflow from exterior watersheds to meet local water demand. Data area available for regional watershed in Africa.

Source: Global Indicators Database for Geospatial indicators  
[http://www.isciences.com/assets/pdfs/GI\\_GlobalDatabase.pdf](http://www.isciences.com/assets/pdfs/GI_GlobalDatabase.pdf)

3. *Water Scarcity Index*: It is the fraction of water overuse, weighted by alternative renewable water resources (desalinated and treated wastewater). The rationale for this index is that overuse of water resources is harming the natural environment. Country level data for 164 countries over the period 1975-2007.

Source: Food and Agricultural Organization, Aquastat.  
<http://www.fao.org/nr/water/aquastat/data/query/index.html>

4. *Access to improved water*: Access to water measures the percentage of a country's population that has access to an improved water source for drinking water. The rationale for this indicator is that diarrheal disease is a leading cause of death among children and is contracted through contaminated water sources. Data are available for 197 countries.

Source: UNICEF and World Health Organization  
[http://www.who.int/water\\_sanitation\\_health/monitoring/jmp2008/en/index.html](http://www.who.int/water_sanitation_health/monitoring/jmp2008/en/index.html)

5. *Access to sanitation*: The percentage of a country's population that has access to improved source of sanitation. Data are available for 195 countries

Source: UNICEF and World Health Organization  
[http://www.who.int/water\\_sanitation\\_health/monitoring/jmp2008/en/index.html](http://www.who.int/water_sanitation_health/monitoring/jmp2008/en/index.html)

### ***Indicators that trace factors affecting water quality and scarcity***

1. *Water use efficiency in urban water use-Non-Revenue Water (NRW)*: NRW is water that has been produced and is "lost" before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). Reduction in nonrevenue water.

<http://www.ib-net.org/en/ibnet-toolkit/ibnet-indicators/non-revenue-water.php?L=2&S=2&ss=3>

2. *Ground water recharge coefficients*:

Source: ESRI ArcAtlas, Our Earth, November 1998  
<http://www.archatlas.dept.shef.ac.uk/virtualglobes/virtualglobes.php>

3. *Runoff coefficients:*

Source: ESRI ArcAtlas, Our Earth, November 1998.  
<http://www.archatlas.dept.shef.ac.uk/virtualglobes/virtualglobes.php>

4. *Precipitation:* Global GIS data on Temperature, Precipitation, Potential and Actual Evapotranspiration, Cloud Coverage.

Source: US Geological Survey (USGS) Global Geographic Information Systems. Available:  
<http://webgis.wr.usgs.gov/globalgis/datasets.htm>

**FAO database and indicators on water**

5. *Agricultural Water Intensity:* Is the annual quantity of water withdrawn for irrigation and livestock purposes, including renewable freshwater resources as well as potential over-extraction of renewable groundwater or withdrawal of fossil groundwater, use of agricultural drainage water desalinated water and treated wastewater. Data are available for 162 countries over the period 1977-2007

6. *Precipitation:* Provides national data on long-term average (over space and time) of annual endogenous precipitation (produced in the country) in depth and in volume.

7. *Surface water produced internally:* Long-term average annual volume of surface water generated by direct runoff from endogenous precipitation (surface runoff) and groundwater contributions.

8. *Groundwater produced internally:* Long-term annual average groundwater recharge, generated from precipitation within the boundaries of the country. Renewable groundwater resources of the country are computed either by estimating annual infiltration rate (in arid countries) or by computing river base flow (in humid countries).

9. *Total Internal Renewable Water Resources (IRWR):* Long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources.

10. *Exploitable water resources:* Water resources or water development potential which is considered to be available for development, taking into consideration factors such as: the economic and environmental feasibility of storing floodwater behind dams, extracting

groundwater, the physical possibility of storing water that naturally flows out to the sea, and minimum flow requirements (navigation, environmental services, aquatic life, etc).

11. *Agricultural water withdrawal*: Annual quantity of water withdrawn for irrigation and livestock purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater, use of agricultural drainage water, desalinated water and treated wastewater.

12. *Municipal water withdrawal*: Annual quantity of water withdrawn primarily for the direct use by the population. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and the potential use of desalinated water or treated wastewater.

13. *Industrial water withdrawal*: Annual quantity of water withdrawn for industrial uses. It includes renewable water resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and potential use of desalinated water or treated wastewater.

14. *Total water withdrawals*: Annual quantity of freshwater withdrawn for agricultural, industrial and municipal purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and eventual use of desalinated water or treated wastewater.

15. *Surface water withdrawal*: Annual gross amount of water extracted from renewable surface water resources.

16. *Groundwater withdrawals*: Annual gross amount of water extracted from aquifers. It includes withdrawal of renewable groundwater, water extracted from deep fossil aquifers (non-renewable water) and potential over-abstraction of renewable groundwater.

17. *Total freshwater withdrawal*: This is the sum of surface water withdrawal and groundwater withdrawal.

18. *Desalinated water produced*: Water produced annually by desalination of brackish or salt water. It is estimated annually on the basis of the total capacity of water desalination installations.

19. *Percentage of total actual renewable freshwater resources withdrawn*: Total freshwater withdrawn in a given year, expressed in percentage of the actual total renewable water resources.

20. *Percentage of total actual renewable water resources withdrawn by agriculture*: Water withdrawn for irrigation in a given year, expressed in percent of the total actual renewable water resources.

21. *Annual gross amount of water extracted from renewable surface water resources:*

Source: Food and Agricultural Organization, Aquastat.

<http://www.fao.org/nr/water/aquastat/data/query/index.html>

### **Impacts of water quality and scarcity**

Burden of disease expressed as disability adjusted life years (DALYs) is a health gap measure that extends the concept of potential years of life lost (PYLL) due to premature death to include equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability from poor water, sanitation and hygiene; indoor air pollution; urban air pollution; lead exposure; and climate change. Data available for 192 countries, and the most recent years available is 2004. DALYs are available for deaths due to all causes and also for waterborne diseases which are useful indicators of the impacts of water quality. Data at the national level are also available for men and women:

[http://www.who.int/quantifying\\_ehimpacts/national/countryprofile/intro/en/index.html](http://www.who.int/quantifying_ehimpacts/national/countryprofile/intro/en/index.html) and

[http://www.who.int/quantifying\\_ehimpacts/publications/preventingdisease/en/index.html](http://www.who.int/quantifying_ehimpacts/publications/preventingdisease/en/index.html)

### **Indicators of land and soil degradation in developing countries**

#### *Indicators to assess land and soil degradation*

1. *Global Assessment of Human-Induced Soil Degradation:* The UNEP-funded, GLASOD project (1987-1990) has produced a world map of human-induced soil degradation mapped within loosely defined physiographic units (polygons), based on expert judgment. The type, extent, degree, rate and main causes of degradation are available on a global map, at a scale of 1:10 million, and documented in a downloadable database.

Source: ISRIC- World Soil Information.

<http://www.isric.org/UK/About+ISRIC/Projects/Track+Record/GLASOD.htm>

2. *Soil Degradation in South and Southeast Asia (ASSOD):* Map of human induced soil degradation in 16 countries in South and Southeast Asia (1995-1997). The information was stored in a digital database and linked to a GIS enabling preparation of thematic outputs in the form of maps, graphs and tables.

Source: <http://www.isric.org/UK/About+Soils/Soil+data/Geographic+data/Regional/default.htm>

3. *Soil Degradation Assessment in Central and Eastern Europe:* The status of soil degradation in Central and Eastern Europe with the associated databases and technical documentation are available in FAO's Land and Water Digital Media Series. Provides information in the form of databases, maps and reports on soil types, on the soil degradation status and gives a soil vulnerability assessment for eleven metals in thirteen countries in Central and Eastern Europe.

4. *Normalized Difference Vegetation Index (NDVI)*: is a numerical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. Data set is available on a 16 day basis for the six year period between 2001 and 2006. The product is derived from bands 1 and 2 of the Moderate-resolution Imaging Spectroradiometer on board NASA's Terra satellite. A time-series of NDVI observations can be used to examine the dynamics of land degradation and vegetation cover.

Source: Global Land Cover Facility <http://www.landcover.org/data/ndvi/description.shtml>

5. *LADA Database on land degradation*: LADA database provides more than 1000 records of data, documents, maps, statistics etc. related to land degradation in drylands. The LADA project is an ongoing activity and has generated maps and data on the following set of indicators:

5.1. *Net Primary Production (NPP)*: NPP is defined as the net flux of carbon from the atmosphere into green plants per unit time.

5.2. *Climatic indicators of land degradation*

a. *Historical trends in precipitation*: Historical monthly precipitation data of VASCLIMO (Global Precipitation Climatology Centre -GPCC) was used.

b. *Aridity* is expressed as the ratio of precipitation over potential evapotranspiration

c. *Length of Growing Period in days (LGP)*: The length of growing period is defined as the number of days when both water availability and prevailing temperatures permit crop growth.

d. *Fournier Index* which provides a measure of the amount and distribution of precipitation is defined as quotient of the squared sum of rainfall of wettest month of the year to the annual rainfall.

5.3. *Land cover indicators*

a. *Land use and land cover inventory*: A land cover map and inventory provides a broad overview of land cover/land use.

b. *Land cover factor*: The spatially detailed global land cover factor inventory is derived from the land use/land cover inventory share maps.

5.4. *Soil and terrain indicators*

a. *Soil erodibility factor and terrain slope factor*: It represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition

Source: FAO <http://www.fao.org/lada/>; <http://lada.virtualcentre.org/pagedisplay/userguide.htm>

The direction and trends and slope coefficients for the above indicators over 1980-2000 are available at:

[http://www.fao.org/nr/lada/index.php?option=com\\_docman&task=cat\\_view&gid=18&Itemid=165&lang=en](http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=18&Itemid=165&lang=en)

Spatially detailed estimates of the above indicator at 5 arc-minute resolution are available on a designated IIASA ftp site for download:

<http://www.filewatcher.com/b/ftp/ftp.iiasa.ac.at.0.0.html>

### **Indicators for tracing land and soil degradation at the local/regional level**

Below are some of the proposed indicators that could be used at the local/regional level to trace land and soil degradation: Water logging, land use and cover, land-use compatibility index, economic productivity, poverty and food insecurity, crop yield forecasting and crop cover and land pollution. FAO under the LADA project is in the process of collecting possible data on the above indicators.

### **Indicators to trace the factors that lead to land and soil degradation**

1. *Population pressure/density*:

Source: World Bank, World Development Indicators <http://www.worldbank.org/data>

2. *Fertilizer use intensity* is the amount of fertilizer consumed for agriculture per hectare of temporary and permanent cropland. Data are in terms of kilograms per hectare and reported on an annual basis. Data are available for most countries and regions from 2002 to 2007 and earlier data can be obtained from FAO archives; however, methodology changed in 2002

Source: Food and Agriculture Organization of the United Nations (FAO). 2009. FAOSTAT Online Statistical Service. Rome: FAO. Available online at: <http://faostat.fao.org>

### **Indicators of deforestation, forest degradation and forest conversion**

#### *Indicators to assess deforestation*

1. *FAO database on forest coverage and deforestation*: The FAO database provides data on the following variables:

- a. Natural forest area, average annual percent change refers to the average annual percent change in natural forest area.
- b. Total forest area, average annual percent change refers to the average annual percent change in total forest area.

- c. Forest plantations area, average annual percent change indicates the average annual percent change in forest plantations area during the period specified.

The above databases cover 229 countries for the periods 2000-2005 and 1990-2000. The database is from FAOs Global Forest Resources Assessment (FRA.) and is conducted once in every five years.

*Source:* Food and Agriculture Organization of the United Nations (FAO). 2005. Global Forest Resources Assessment 2005: Progress towards sustainable forest management. FAO Forestry Paper 147. Rome: FAO. Available online at:

<http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=101&langId=1>  
[http://earthtrends.wri.org/searchable\\_db/index.php?theme=9](http://earthtrends.wri.org/searchable_db/index.php?theme=9)

2. *Landsat Pathfinder Humid Tropical Deforestation database:* The Landsat database has GIS based deforestation maps for the Amazon Basin, Central Africa, and Southeast Asia for three periods in the 1970s, 1980s, and 1990s.

*Source:* NASA Landsat Pathfinder Humid Tropical Deforestation Project  
<http://www.geog.umd.edu/tropical/>

3. *Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER):* provides detailed satellite pictures of deforestation at a higher resolution.

*Source:* NASA and California Institute of Technology <http://asterweb.jpl.nasa.gov>

4. *Moderate Resolution Imaging Spectroradiometer (MODIS) database:* provides daily portrait of tropical forests at a spatial resolution of 250 meters per image pixel to develop an annual set of images showing where human-caused changes in vegetation—including deforestation and burning—have occurred in the previous year.

*Source:* <http://modarch.gsfc.nasa.gov/>

### **Indicators to trace the causes of deforestation**

1. *Urbanization:* Growth rate of urban population: Average annual percent growth of the midyear population in areas defined as urban. This dataset has data for most countries and has estimates from 1950 to 2050 in five year intervals and forecasts for 2010 to 2050.

*Source:* United Nations, Department of Economic and Social Affairs, Population Division.  
<http://esa.un.org/unup/>; [http://earthtrends.wri.org/searchable\\_db/index.php?theme=4](http://earthtrends.wri.org/searchable_db/index.php?theme=4)

2. *Total population in cities with more than one million inhabitants:* Refers to the number of people living in cities that have a population greater than 1,000,000. This dataset contains estimates for 2002 with updates the site on an on-going basis.

Source: The World Bank Group. 2004. Urban Population in World Bank Regions by City Size. Available on-line at: <http://www.worldbank.org/urban/env/population-regions.htm>

3. *Total population in cities with more than 100,000 inhabitants* refers to the number of people living in cities that have a population greater than 100,000. . This dataset contains estimates for 2002 with updates the site on an on-going basis.

Source: The World Bank Group. 2004. Urban Population in World Bank Regions by City Size. Available on-line at: <http://www.worldbank.org/urban/env/population-regions.htm>

5. *Urban Population as a Percent of Total Population* is the proportion of a country's total national population that resides in urban areas. This dataset contains estimates for most countries from 1950 to 2030 in five year intervals and forecasts for 2010 to 2030. This dataset also has data on urban population referred to as the midyear population of areas defined as urban.

Source: United Nations, Department of Economic and Social Affairs, Population Division. <http://esa.un.org/unup> ; <http://earthtrends.wri.org>

6. *Agricultural expansion*-Data on agricultural area for most countries from 1960-2007. Growth in agricultural area is an indicator of agricultural expansion.

Source: FAO <http://faostat.fao.org>

7. *Wood fuel production*: Wood fuel refers to all roundwood used as fuel for purposes such as cooking, heating, or power production. Data are available for most countries and regions from 1961 to 2006 and are updated annually with updates for 2008.

Source: Food and Agriculture Organization of the United Nations (FAO). 2008. FAOSTAT Online Statistical Service. Rome: FAO. Available online at: <http://faostat.fao.org>

8. *Roundwood production* includes all wood in the rough, whether destined for industrial or fuelwood uses. Data are available for most countries and regions from 1961 to 2006 with the most recent update in 2008.

### **Indicators to trace the effects of deforestation**

The effects of deforestation include, among other things, land and soil degradation, disruption of water cycle, loss of biodiversity, flooding, draught, other natural disasters and climate change. Indicators on these variables/environmental problems have been dealt with elsewhere in the report.

## Natural disasters

This section will present information on available data sources on natural disasters at the global, regional, national levels and disaster level databases.

### *a. Global databases*

1. *EM-DAT International Disaster Database*: Since 1988 the WHO Collaborating Center for Research on the Epidemiology of Disasters (CRED) has created and maintained the EM-DAT. EM-DAT is a global database on natural and technological disasters that contains essential core country-wise data on the occurrence and effects of more than 17,000 disasters in the world from 1900 to present. The database covers the disaster groups like natural, biological, climatological, geographical, hydrological, meteorological, and technological disasters. The different disaster types include complex disasters, draught, earthquake, epidemics, extreme temperature, flood, industrial accident, insect infestation, mass movement, miscellaneous accident, storms, transport accidents, volcanoes and wildfires. For each disaster the database provide information on the start and end dates, country and location, disaster type, the number affected, killed and the estimated damage from the disaster.

Source: <http://www.emdat.be>

2. Munich Reinsurance Company NatCat: A private international database with exhaustive coverage from 1980 to the present with over 20,000 entries and 800 new entries per year entered on country and event levels.

Source: [http://www.munichre.com/publications/302-03901\\_en.pdf](http://www.munichre.com/publications/302-03901_en.pdf)

3. ADRC-GLIDE: The Global Disaster Identifier Number (GLIDE) is a database initiated and maintained by the Asian Disaster Reduction Center (ADRC) in collaboration with ISDR, CRED, UNDP, IFRC, FAO, World Bank, OFDA/USAID, LARed and OCHA. The GIDE database is searchable by date, disaster type, country, and Glide number

Source: <http://www.glidenummer.net>

4. University of Richmond disaster database: An international database searchable by type of disaster, disaster class, year, location, or maidenhead grid.

Source: <http://learning.richmond.edu/disaster/index.cfm>

5. BASICS: British Association for Immediate Care (BASICS) is a database of natural and technological disasters, with 7500 records searchable by type, location, date, number of people affected and other comments. Source: <http://www.basics.org.uk/data/searchPage.php>

### *b. Regional disaster databases*

1. *La RED database*: This database has details of about 44,000 disaster events in Latin America covering for about 30 years.

Source: <http://www.desinventar.org>

2. *Asian Disaster Reduction Center database* provides information on natural disasters in countries in Asia and Southeast Asia from 1998 till present.

Source: [http://adrc.or.jp/disaster\\_innformation\\_aca.php](http://adrc.or.jp/disaster_innformation_aca.php)

#### c. National databases

Information on national disaster databases for Australia, Canada, United States and Philippines are given below:

1. Emergency Management Australia (EMA) database:  
<http://www.ema.gov.au/ema/emaDisasters.nsf>
2. Canada Disaster database: Source: <http://www.publicsafety.gc.ca/res/em/cdd/search-en.asp>
3. United States SHIELDUS database: Source: <http://www.shieldus.org>
4. United States national Hazard Statistics: Source:
5. <http://www.weather.gov/om/hazstats.shtml>
6. Philippines National Disaster Coordinating Council database:  
Source: <http://www.ndcc.gov.ph> ; <http://disaster.dswd.gov.ph>

#### d. Sub-national databases

1. *South Africa Monitoring, Mapping, Analysis of Disaster Incidents* (MANDISA) has record of disasters in South Africa from 1990 to 2006.  
Source: <http://www.egs.uct.ac.za/dimp>
2. *UNDP/NSET: Nepal dataset*: The National Society for Earthquake Technology (NSET), an NGO in Nepal, has developed a disaster database in collaboration with UNDP with records from 2003 up to 2006. Source: <http://undp.desinventar.net/DesInventar/index.jsp>
3. *UNDP: Sri Lanka disaster database*: Database on natural disasters technological disasters in Sri Lanka covering 1974-2006. Source: <http://undp.desinventar.net/DesInventar/index.jsp>
4. *UNDP Orissa database*: This database has information on disasters in North Indian State of Orissa covering the period 1970-2006: <http://undp.desinventar.net/DesInventar/index.jsp>

e. *Disaster event specific databases*: In addition to the above, a list of sources for event specific disasters like earth quake, floods, Tsunami, technological disasters is available at the following site: <http://www.em-dat.net/documents/Publication/TschoeglDataSetsReview.pdf>

### **Indicators of impacts on biodiversity, ecosystems and protected areas**

1. *Number of species extinct and number of species threatened*: National data on the number of Amphibian, bird, fish, mammal, plants, reptile, tree, and vascular plant species that are extinct and threatened over 1990-99 period.

Sources: <http://www.earthtrends.wri.org>

The primary sources for the above data are:

*Extinct and extinct in the wild species data* are from WCMC and World Conservation Union (IUCN), 1996 IUCN Red List of Threatened Animals (IUCN, Gland, Switzerland, 1996), [http://www.wcmc.org.uk/species/animals/animal\\_redlist.html](http://www.wcmc.org.uk/species/animals/animal_redlist.html)

*Number of threatened and extinct species of trees* is from the Tree Conservation Database, World Conservation Monitoring Centre (WCMC).

[http://www.wcmc.org.uk/trees/Background/country\\_stats.htm](http://www.wcmc.org.uk/trees/Background/country_stats.htm)

<http://www.unep-wcmc.org>

2. *Number of World Heritage sites in danger*: National data on number of endangered sites that are considered to be in danger as of 2007.

Source: World Heritage Committee, United Nations Educational, Scientific, and Cultural Organization (UNESCO). 2004. List of World Heritage Sites in Danger. Available on-line at: <http://whc.unesco.org/pg.cfm?cid=86>; <http://www.earthtrends.wri.org>

3. *Global trade in species and wildlife*: Data on global trade reported in earth trends database of the World Resources Institute.

Source: World Conservation Monitoring Centre of the United Nations Environment Program (UNEP-WCMC). July 2004. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) annual report data, World Conservation Monitoring Centre (WCMC) CITES Trade Database. Available on-line at: <http://www.cites.org>

4. *Marine Trophic Index*: Developed by the Sea Around Us project at the UBC Fisheries Centre, and was established to investigate the impacts of fisheries on the world's marine ecosystems. Data is available only through 2002.

Source: Pauly, D. and R. Watson. 2005. Background and interpretation of the 'Marine Trophic Index' as a measure of biodiversity. *Philosophical Transactions of the Royal Society: Biological Sciences* 360: 415-423. <http://www.seaaroundus.org>

## **Environmental governance and institutions**

This section presents the available indicators on environmental institutions and governance for sustainable management of environment and natural resources in developing countries.

1. *Status of multilateral agreements*: Year of ratification and or signing of the following multilateral agreements:

- Aarhus Convention (access to environmental information)
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal <http://www.basel.int/index.html>
- Cartagena Protocol on Biosafety <http://www.biodiv.org/world/parties.asp>
- Convention on International Trade in Endangered Species of Wild Fauna and Flora, or CITES: <http://www.cites.org/eng/disc/parties/alphabet.shtml>
- Convention on Migratory Species: [http://www.cms.int/pdf/en/party\\_list/Partylist\\_eng.pdf](http://www.cms.int/pdf/en/party_list/Partylist_eng.pdf)
- Kyoto Protocol (CO2 emissions) [http://unfccc.int/files/essential\\_background/kyoto\\_protocol/application/pdf/kpstats.pdf](http://unfccc.int/files/essential_background/kyoto_protocol/application/pdf/kpstats.pdf)
- Ramsar convention on conservation and wise use of wetlands: [http://ramsar.org/key\\_cp\\_e.htm](http://ramsar.org/key_cp_e.htm)
- The Stockholm Convention on international legally binding instrument designed to protect human health and the environment from persistent organic pollutants: <http://www.pops.int/documents/signature/signstatus.htm>
- The United Nations Convention on the Law of the Sea all uses of the oceans and their resources: <http://www.un.org/Depts/los/index.htm>
- United Nations Convention to Combat Desertification (UNCCD): <http://www.unccd.int/main.php>
- The United Nations Framework Convention on Climate Change (UNFCCC): <http://www.un.org/geninfo/bp/enviro.html>

- The Vienna Convention on the Protection of the Ozone Layer:  
[http://www.unep.ch/ozone/Treaties\\_and\\_Ratification/index.asp](http://www.unep.ch/ozone/Treaties_and_Ratification/index.asp)
  - World Heritage Convention on protection of World Cultural and Natural Heritage.  
<http://whc.unesco.org>
2. *National Agenda 21 Reporting Status*: indicates if a country has submitted a report on the status of its implementation of Agenda 21 in relation to the specific themes to promote sustainable development.
  3. *Country Policy and Institutional Assessment (CPIA) scores* on environmental management and governance: <http://go.worldbank.org/74EDY81YU0>
  4. There is tracking in most countries of men and women elected to office and this could be further refined to track men and women's representation in national-level environmental institutions and bodies.

## Annex 2. Other resources consulted

BP. <http://www.bp.com>, <http://www.facebook.com/BPAmerica>, <http://www.youtube.com/bp>.

Distant Early Warning System. [http://www.dews-online.org/front\\_content.php](http://www.dews-online.org/front_content.php)

Global Monitoring for Environment and Security. <http://www.gmes.info>

Global Reporting Initiative. <http://www.globalreporting.org>

Group on Earth Observation. [http://www.earthobservations.org/about\\_geo.shtml](http://www.earthobservations.org/about_geo.shtml)

Houghton, John, 2009, ICT and the Environment in Developing Countries: Opportunities and Developments. <http://www.oecd.org/dataoecd/40/25/43631894.pdf>

IFC, 2006, Policy on Social and Environmental Sustainability. [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol\\_SocEnvSustainability2006/\\$FILE/SustainabilityPolicy.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol_SocEnvSustainability2006/$FILE/SustainabilityPolicy.pdf)

IFC, 2010, Getting More Value Out of Sustainability Reporting. Road Test Version. [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p\\_GettingMoreValue/\\$FILE/WB\\_IFC\\_GettingMoreValue.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_GettingMoreValue/$FILE/WB_IFC_GettingMoreValue.pdf)

Integrated Biodiversity Assessment Tool. <http://www.ibatforbusiness.org>

Labelle, Richard, ICT Linkages to Climate Change – Trends and Potential Interventions, World Bank (CITPO), Ver.1.03. Final Report.

ITU and Climate Change. <http://www.itu.int/themes/climate>

ITU, 2008, ICTs for e-Environment: Guidelines for Developing Countries, with a Focus on Climate Change. <http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf>

Obiso, Marco, 2009, e-Environment and the Use of ICTs for Environmental Monitoring, ITU. [http://www.itu.int/ITU-D/cyb/app/docs/The\\_Use\\_of ICTs\\_for\\_Environmental\\_Monitoring.pdf](http://www.itu.int/ITU-D/cyb/app/docs/The_Use_of ICTs_for_Environmental_Monitoring.pdf)

Planetary Skin. <http://planetaryskin.org>

Shell. [http://www.shell.com/home/content/environment\\_society/performance/environmental/dir\\_env\\_performance.html](http://www.shell.com/home/content/environment_society/performance/environmental/dir_env_performance.html)

The Climate Group and GeSI, 2008, SMART 2020: Enabling the Low Carbon Economy in the Information Age. [http://www.smart2020.org/\\_assets/files/02\\_Smart2020Report.pdf](http://www.smart2020.org/_assets/files/02_Smart2020Report.pdf)

The Equator Principles. <http://www.equator-principles.com>

The World Bank, 2010, ICT Linkages to Climate Change – Potential WBG Interventions.

United Nations Framework Convention on Climate Change. <http://unfccc.int/2860.php>

United Nations Environment Programme, Atlas of Our Changing Environment. [http://na.unep.net/digital\\_atlas2/google.php](http://na.unep.net/digital_atlas2/google.php)

United Nations Global Compact. <http://www.unglobalcompact.org>

United Nations. Principles for Responsible Investment. <http://www.unpri.org>

USAID, Program Summary: US Indian Ocean Tsunami Warning System (IOTWS) Program. [http://usaid.eco-asia.org/files/fact\\_sheets/IOTWS.pdf](http://usaid.eco-asia.org/files/fact_sheets/IOTWS.pdf)

World Atlas of Biodiversity. <http://bure.unep-wcmc.org/imaps/gb2002/book/viewer.htm>

## Annex 3. The IFC Appraisal and Supervision process

IFC monitors the environmental and social performance of its investments and manages associated risks at the beginning of an investment and as part of its ongoing portfolio management.

The scope and regularity of reporting that IFC requires from clients are determined for each investment depending on:

- The sector and type of business
- The nature and level of risks identified
- The nature of the investment (e.g. loan or equity)

These aspects are explained to the public through IFC's Disclosure Portal ([www.ifc.org/disclosure](http://www.ifc.org/disclosure)) for every investment before approval by IFC's Board of Directors.

Information is used during the Appraisal stage to:

- Understand the nature of the business (governance, strategy, systems)
- Ascertain the scope of impact of the company's operations (affected stakeholders; scope of influence)
- Assess environmental and social impacts and risks
- Assess the company's Action Plan to address their environmental and social risks and impacts
- Identify business opportunities that can be achieved through greater sustainability (e.g. efficient energy use, more effective waste management, improved labor standards)

Information is used during the Supervision stage to:

- Monitor implementation of Action Plans and ensure that the client remains in compliance with the Performance Standards
- Identify any new risks arising from operations (e.g. environmental impacts or relations with employees or the community)
- Assist companies to improve their E&S management systems and performance over time
- Work with the client to develop business opportunities through sustainability (e.g. carbon finance, renewable energy, access to finance for women)

*Source: IFC, 2010, p11*

## Development Outcome Tracking System Indicators

Indicators	
Air Pollutant Emissions (mg/Nm3) – Nox	Resettlement (#) and Livelihood Restoration (#)
Air Pollutant Emissions (mg/Nm3) - Other Pollutant	Use of Hazardous Materials (kg)
Air Pollutant Emissions (mg/Nm3) – PM	Use of Internationally Controlled Substances (Y/N)
Air Pollutant Emissions (mg/Nm3) – Sox	Use of Organic Waste (kg)
Air Pollutant Emissions (mg/Nm3) – VOC	Waste: Hazardous Waste Production (%)
CO2 Equivalent Emissions (MT)	Waste: Reuse & Recycling (%)
Community Development Outlay (\$) and (#)	Water Consumption & Efficiency
E&S Management Systems (Y/N)	Water Pollution (mg/L) – BOD
Energy Consumption from Renewables	Water Pollution (mg/L) – COD
Energy Consumption per Unit	Water Pollution (mg/L) – Other
Land Disturbed & Rehabilitated (Ha)	Water Pollution (mg/L) – TSS
Occupational Injury: Incidence Ratio (per million people-hours)	Water Recovered For Secondary Use* (m3)
Occupational Injury: Severity Rate (per million people-hours)	

Source: IFC