Chapter 2

Physical Indicators of Potential Changes in Environmental Pressures and Environmental Impacts

Energy and transport

This section examines projected changes in energy, industry and transport-related demand for final energy services by source and for primary sources of energy for producing electricity. The models used to develop these projections have been calibrated to the projections prepared by the IEA in its *World Energy Outlook 2004*. The projections used in the EO are slightly higher than those of IEA, however, because of differences in the assumptions about economic growth.

The demand for total world-wide energy services in the baseline scenario is projected to increase from 279 exajoules (EJ) in 2000 to 472 EJ in 2030, an increase of more than 69%. Most of the growth of both population and energy use is projected to occur in developing countries. Thus, energy consumption of developing countries is expected to double over the same period. This will result in a significant shift in regional shares of world energy consumption, with the share of OECD countries falling from 53% in 2000 to 43% by 2030, with corresponding increases in the shares of many developing countries and regions. On a per capita basis, little growth is expected in OECD countries since energy efficiency gains are expected to just about match the increases in the demand for energy services. Developing countries per capita energy use is projected to increase from less than 100 gigajoules (GJ) to nearly 125 GJ over the same period, thus narrowing the gap with the OECD countries. Electricity demand is expected to more than double in absolute terms, while the demand for non-electric energy use in transport, industrial processes, heating, etc. is expected to increase by about 50%.

Country and regional shares in the primary inputs used for electric power exhibit similar changes to those for total energy use. The share of the 4 BRIC countries (Brazil, Russia, India and China) is expected to increase from 32% in 2005 to 36% in 2030, and that of the other developing and transition economies (the "rest of the world" or ROW) is expected to increase from 15% to 18% over the same period.

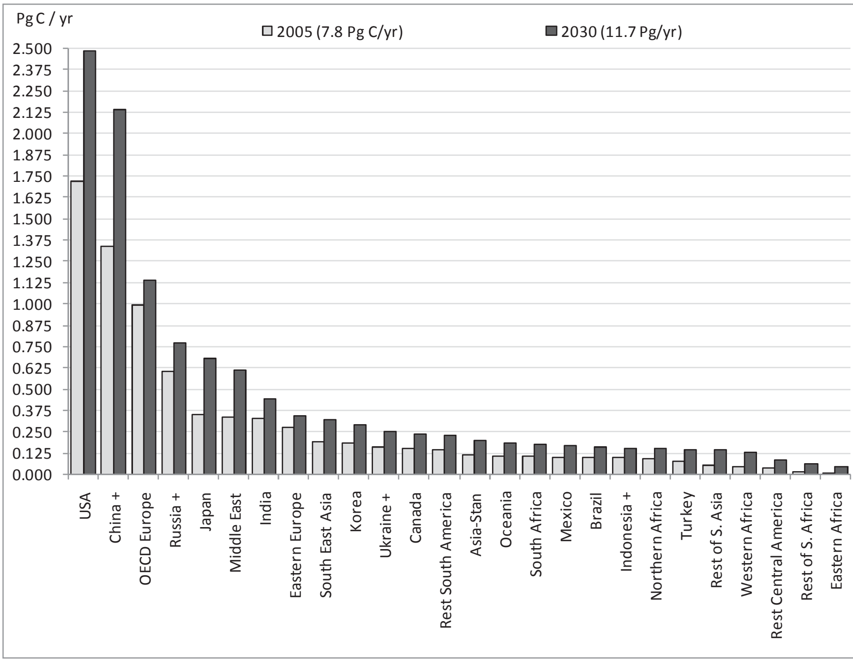
Between 2005 and 2030, the use of coal in electricity production is expected to continue to increase by 71%, and the use of other fuels by about the same amount, such that the share of coal will remain at about 55%. The share of the 4 BRIC countries in the use of coal for electricity is expected to increase from 39% in 2005 to 46% in 2030, while that of the other developing and transition economies, the (ROW), is expected to increase from 9% in 2005 to 12% in 2030. Increases in the use of coal are proportionately very large in many developing and transition countries and regions (China, 122%; S. Asia, 163%; other East and Southeast Asia, 276%; Africa, 149%).

Table 2.1. Use of coal in electricity production by region, 2005 and 2030 (percentage)

	2005	**2030**
OECD	51.86	42.19
Russia	8.59	4.28
Other developed economies	2.60	1.14
China +	24.15	31.49
Indonesia +	1.00	1.82
South East Asia	1.49	3.68
India	6.48	9.58
Rest of S. Asia	0.05	0.51
Middle East	0.52	0.91
Northern Africa	0.12	0.29
Western Africa	0.01	0.05
Eastern Africa	0.00	0.21
South Africa	2.46	2.47
Rest of S. Africa	0.15	0.96
Brazil	0.16	0.20
Rest South America	0.35	0.17
Rest Central America	0.02	0.05
World total levels (PJ/yr)	**86 509**	**147 640**

Source: Env-Linkages/IMAGE model analysis.

Figure 2.1. GHG emissions from energy and transport, 2005 and 2030 (Pg C/Yr)

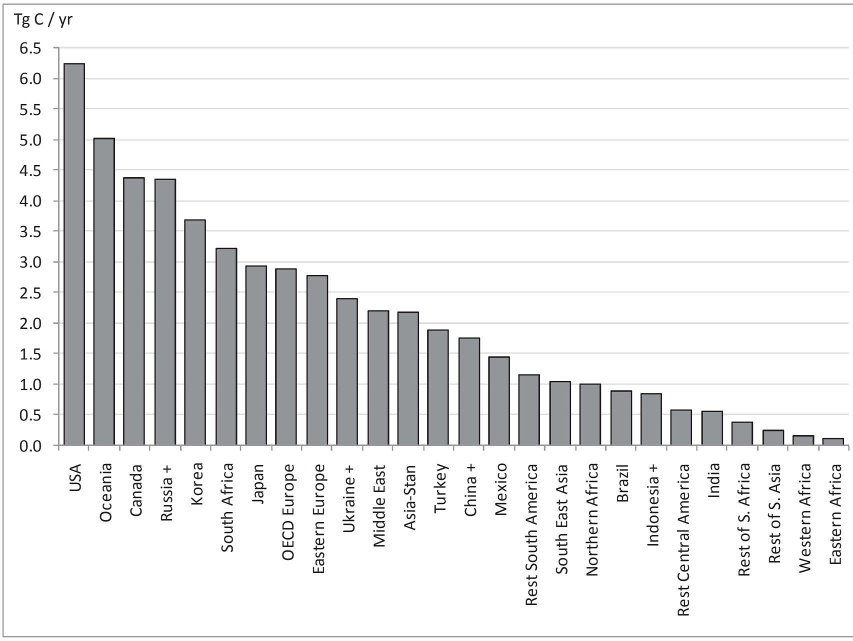


Source: Env-Linkages/IMAGE model analysis.

The emissions of greenhouse gases associated with energy and transport in the baseline scenario are projected to increase from 7.8 Pg C-equivalent in 2005 to 11.7 Gt C-equivalent in 2030, an increase of 50%. Thus, as may be seen in Figure 2.1, the combined share of developing and transition economies in world GHG emissions is projected to increase from 49% in 2005 to 58% in 2030.

Of course, energy-related greenhouse gases emitted by developing countries are projected for 2030 to remain much lower on a per capita basis than in OECD countries as may be seen from Figure 2.2. China, Middle East, Northern Africa, the Republic of South Africa, Brazil, other Latin American countries, Indonesia, and other East and Southeast developing countries are projected to reach per capita levels above or slightly below the world average.

Figure 2.2. Emissions per capita (Tg C/Yr) in 2030



Source: Env-Linkages/IMAGE model analysis.

Agriculture and land use

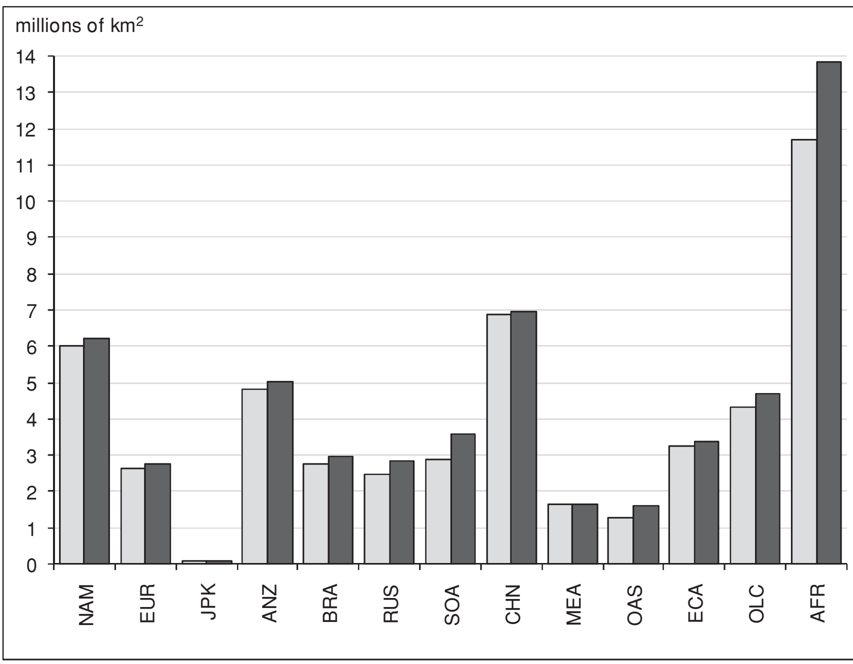
This section describes changes in land used for food crops and for animal husbandry, the pattern of agricultural production worldwide, and trade in agricultural products. It thus expands on the discussion of changing economic sector shares linked to macro-economic developments in section 1. Projected developments with respect to agriculture and land use have implications for greenhouse gas emissions, nitrogen deposition and exceedance, nutrient loading of soils and surface water, water stress, and biodiversity.

Increasing population and per capita incomes are projected to increase the demand for agricultural products, which are projected to grow at about 1.6% per year from 2005 to 2030, much more slowly than overall economic activity. Growth of animal products, oilseeds, and oil-crops are projected to outpace agricultural production generally with the slowest growth expected for rice and milk. Per capita consumption of agricultural products is expected to grow more rapidly in BRIC and ROW countries than in OECD countries. Production of processed agricultural products is projected to grow more rapidly than primary production, especially so in developing countries.

Agricultural export growth is expected to grow more rapidly than production, with exports from BRIC and other developing countries set to outpace growth in exports by OECD countries.

The total area used for agriculture is projected to expand by 9.5% between 2005 and 2030 although total agricultural outputs are expected to increase by 73%. This is mainly because of an assumption that agricultural productivity will continue to increase rapidly, mainly in developing countries. But it also reflects projections that land used for food crops will increase by about 16% while land used for grass and fodder will increase by 5.6%. Increases in crop areas are projected to be largest in Africa, with substantial increases in Brazil, other Latin American countries, and South Asia.

Figure 2.3. Total crop area by major world regions, 2005 and 2030



Note: Regional country groupings are as follows: **NAM**: North America (United States, Canada and Mexico); **EUR** (western and central Europe and Turkey); **JPK:** Japan and Korea region; **ANZ:** Oceania (New Zealand and Australia); **BRA:** Brazil; **RUS:** Russia and Caucasus; **SOA:** South Asia; **CHN:** China region; **MEA:** Middle East; **OAS:** Indonesia and the rest of South Asia; **ECA:** eastern Europe and central Asia; **OLC:** other Latin America; **AFR:** Africa.

Source: Env-Linkages/IMAGE model analysis.

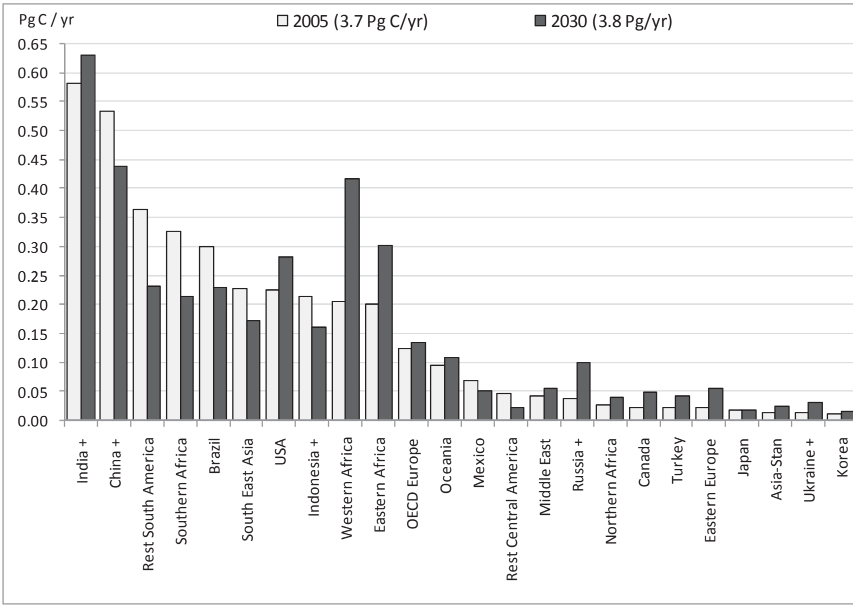
These projected developments for land use and changes in production patterns have implications for emissions of the greenhouse gases, methane and nitrous oxide, as well as carbon dioxide, and for water quality.

As far as methane emissions are concerned, more efficient production in intensive production systems and changes in diet are assumed to lead to lower emissions per kg of product. Nonetheless, agriculture related methane emissions are projected to increase in total by about 26% between 2005 and 2030 compared with an increase of total food crop production of 73%.

Nitrous oxide emissions arise from soil processes, fertiliser applications, and higher deposition from airborne nitrogen compounds. These are projected to increase by 18% between 2005 and 2030, much more than the increase in the amount of land used for agriculture or in the amount of land used for food crops due to an expected increase in intensive methods of agricultural production.

Carbon dioxide emissions from agriculture are projected to increase as well due to land use clearing that is only partly compensated by increased absorption of CO_2 by the crops themselves. Thus, total GHGs from agriculture worldwide are projected to increase marginally from 3.73 Pg C-eq in 2005 to 3.8 Pg C-eq in 2030, about 22% of the total GHG emissions projected for 2030. As may be seen in the chart below, the share of OECD countries in agricultural GHG emissions is projected to increase from 16% in 2005 to 18% in 2030. The shares of most developing country regions are projected to remain fairly stable except for Western Africa, where agricultural production is expected to expand significantly.

Figure 2.4. Land use emissions by major world regions, 2005 and 2030 (Pg C/yr)



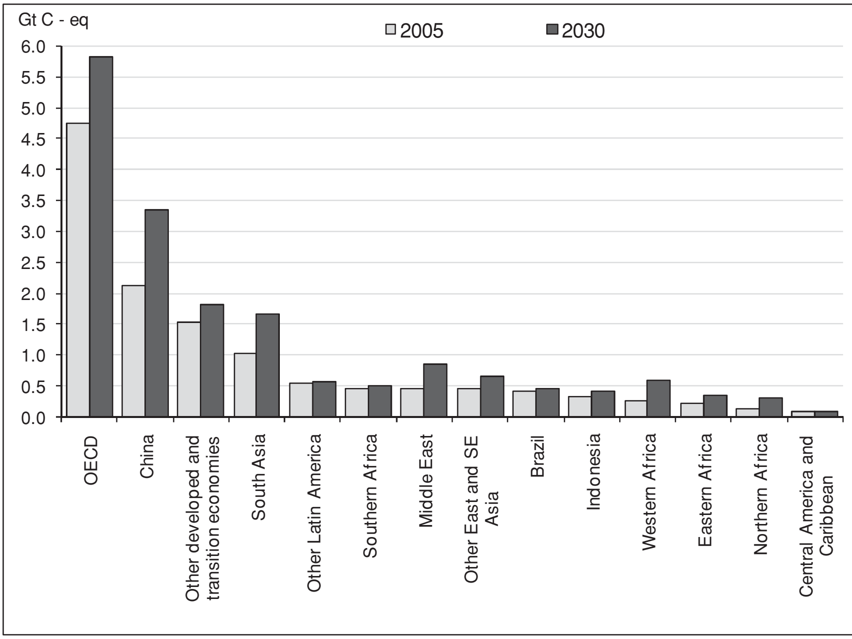
Source: Env-Linkages/IMAGE model analysis.

Global climate change

The factors discussed above are projected to lead to an increase of total anthropogenic GHG emissions from 12.8 Gt C-eq in 2005 to 17.5 Gt C-eq in 2030. OECD and other developed and transition economies would see their combined share fall from about 48% in 2005 to about 43% in 2030. As may be seen from the figure below, large increases are projected in all developing countries and regions, with the largest absolute increases projected for China. Increases in Africa are also projected to be large, especially in Western Africa, and the total amount would be similar to emissions in Latin America.

These emission trends are projected to lead to an increase in GHG concentrations in the atmosphere to 465 ppmv by 2030 and to 543 by 2050. Compared to pre-industrial levels, this will mean an increase in the average mean temperature of 1.2-1.6 degrees C by 2030, and to 1.7-2.4 degrees C by 2050 (OECD, 2008).

Figure 2.5. Anthropogenic emissions of greenhouse gases, 2005 and 2030 (Gt C-eq)

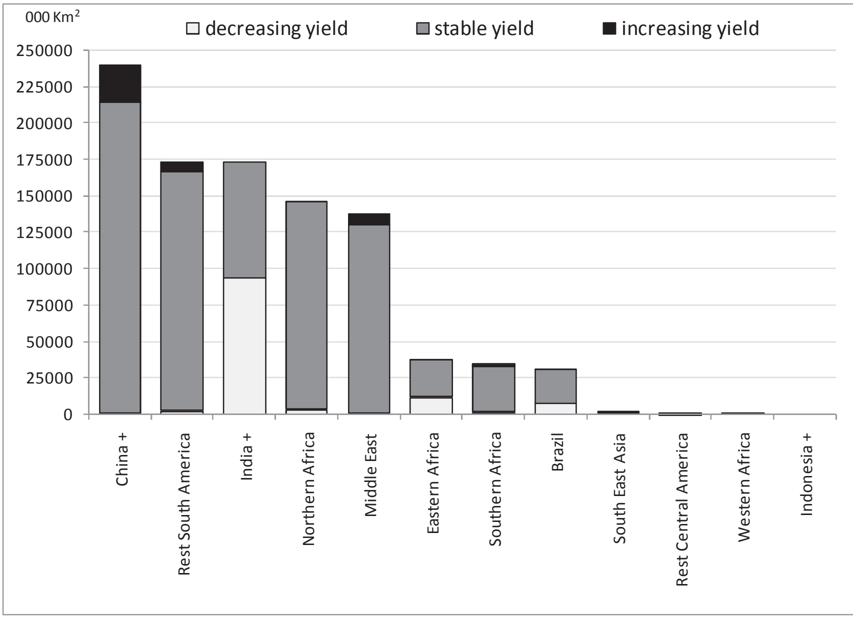


Source: Env-Linkages/IMAGE model analysis.

This global picture of climate change will have different implications for various world regions with, for example effects on the hydrological cycle resulting in regionally differentiated impacts regarding patterns of rainfall, with some regions becoming much dryer than others. The combination of changes in temperature and precipitation will have impacts on agricultural productivity and on the spatial allocation of crops. Figure 2.6 shows the projected changes in the distribution of agricultural land used for temperate cereal crops by the quality of crop yields (increasing, decreasing or stable).

In general, countries nearer to the equator become warmer and dryer. In the production of temperate cereals, South Asian countries are projected to experience large net decreases in yields. In Africa as a whole, a small net decrease in yields is projected as well. In the production of rice, a relatively large net decrease in yields is projected for South Asian countries.

Figure 2.6. Changes in area by quality of crop yields for developing country regions between 1990 and 2030



Source: Env-Linkages/IMAGE model analysis.

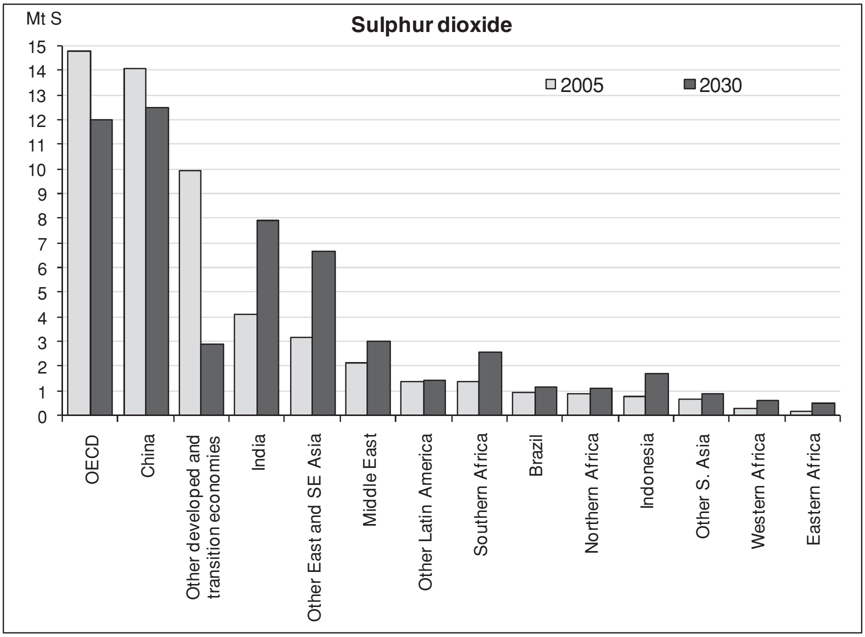
Air pollution

Some of the gases responsible for local air pollution represented in the modelling framework of the EO are sulphur oxides and nitrogen oxides, whose projected trends differ markedly from one another.

Sulphur oxides are produced primarily from combustion of fossil fuels in electricity generation, industrial production, and transport. Reductions in emission coefficients are due to increasingly stringent vehicle standards in OECD countries, which subsequently appear in developing countries with a time lag as the characteristics of their vehicle fleets change over time, and reflecting policies recently implemented in a number of developing and transition economies to install scrubbers in power plants. However, growth of energy intensive sectors and products is projected to increase more rapidly in most developing countries and regions than in OECD countries as has been mentioned earlier. Thus global emissions are projected to decrease slightly by 2030 as a result of strongly declining emissions in OECD countries and economies in transition offset by rising emissions in developing countries, especially in the large BRIC countries. The share of OECD countries in total emissions of sulphur oxides is, thus, projected to fall from about 27% in 2005 to about 22% in 2030. Emissions from BRIC countries are projected to peak in 2015 and to decline slowly thereafter, whereas emissions from other developing countries are projected to continue rising throughout the entire period. As may be seen in Figures 2.7a and 2.7b, increases in emissions are projected to be particularly large in India, Other East and Southeast Asia, noticeably in Africa and in Latin America, but projected to decline in China.

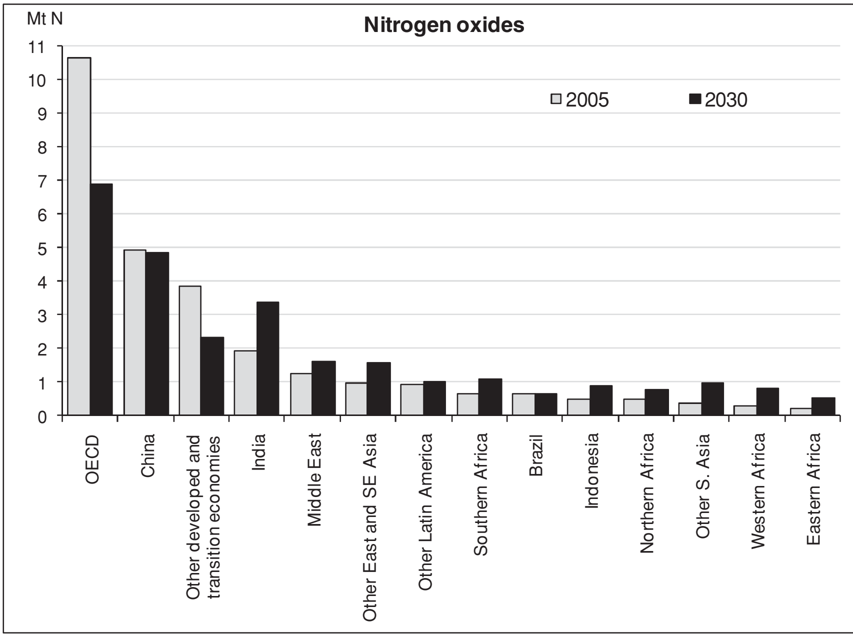
Nitrogen oxides are produced by a broader array of economic activities, especially transport and power generation, and have been harder to reduce until recently. Technical progress in reducing nitrogen oxides from transport has been substantial in recent years, with regulators following suit and increasing the stringency of regulation; thus nitrogen oxides from transport are projected to fall over the projection period. Emissions will, however, increase in other sectors. In OECD countries, they are projected to fall quite steeply overall, but this will be nearly offset by growth in emissions by developing countries. Between 2005 and 2030 emissions worldwide are projected to decrease marginally by 1.3% despite large increases in the underlying drivers. The share of developing countries in total emission of nitrogen oxides will consequently increase from 47% of the global total in 2005 to about 66 % by 2030. As may be seen from Figure 2.8, especially large increases are projected for India and other S. Asia, Indonesia and other East and Southeast Asia. Most regions in Africa also are projected to show sizeable increases. But emissions are projected to decline or stabilise in China, Brazil, and other Latin American countries.

Figure 2.7a. Emissions of sulphur dioxide, 2005 and 2030 (Mt)



Source: Env-Linkages/IMAGE model analysis.

Figure 2.7b. Emissions of nitrogen oxides, 2005 and 2030 (Mt))

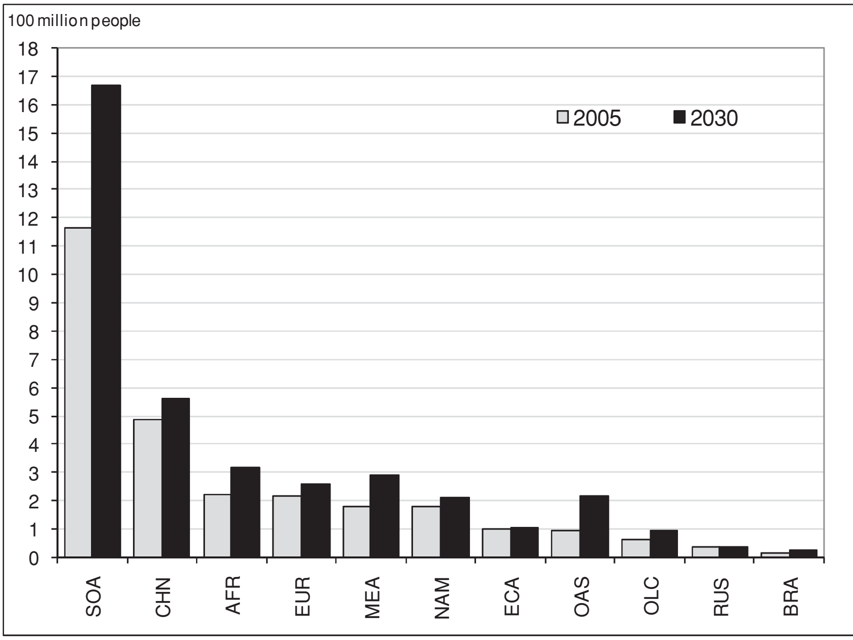


Source: Env-Linkages/IMAGE model analysis.

Freshwater resources

Increasing population and increased economic activity will mean greater demand for water use (abstractions). This will result in an increase of about 1 billion people living in areas subject to high water stress from now to 2030. The model analysis is based on the situation projected in 2030 for the drainage basins of some 6 000 major rivers throughout the world. The numbers of people living in situations of water stress are projected to increase in all developing country regions, with especially large percentage increases projected for South Asia and Africa. The methodology assumes that populations expand proportionately in all river basins within a given region or country.

Figure 2.8. Populations in river basins with severe water stress for selected countries and regions, 2005 and 2030



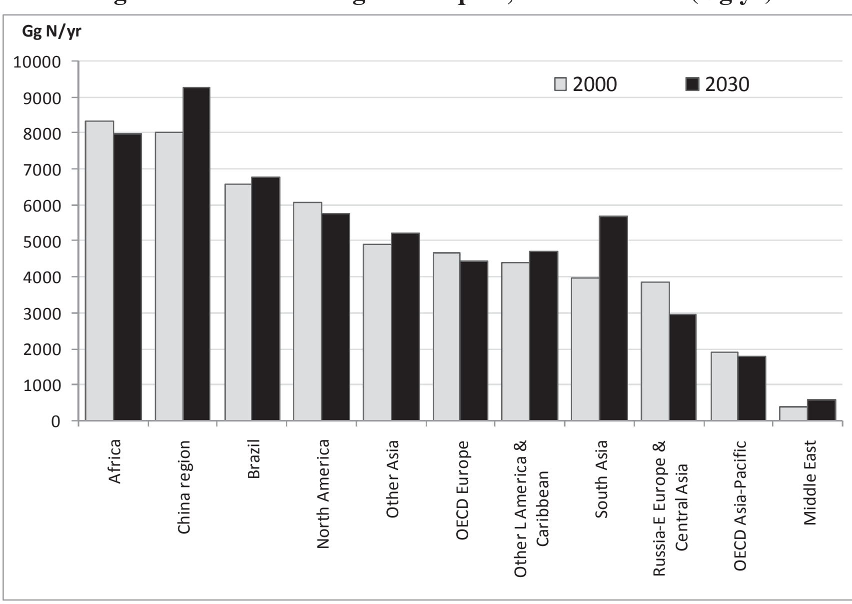
Source: Env-Linkages/IMAGE model analysis.

The baseline scenario thus points to the need to rationalise water use, especially in agriculture, and/or invest in desalination and inter-basin transfers of water to meet the highest priority need of supplying adequate supplies of freshwater to households. Significant population movements from agricultural areas experiencing increases in water stress to other areas may also pose challenges in a number of developing countries. Differences in country/region levels of development and administrative capacity will imply different policy packages tailored to their specific circumstances.

Water quality and coastal marine ecosystems

Impacts on surface water quality and coastal waters are measured by the projected levels of loading with nitrogen compounds. The difference between nitrogen inputs and outputs, the so-called surface nitrogen balance, is projected to increase in all countries and regions considered in this report, driven mainly by increases in intensive forms of agricultural production but also by atmospheric deposition resulting from combustion of fossil fuels in energy and transport. Atmospheric nitrogen deposition exceeding critical levels is projected to increase in Asia and in East Africa. The largest increases in surface nitrogen balances are projected to occur in Asian regions and in OECD Europe. The surplus nitrogen enters into ground water and surface water bodies where denitrification and retention reduce the amount of reactive nitrogen compounds. The amount of surplus nitrogen resulting from agricultural practices and entering into water bodies is augmented by discharges from sewage water when wastewater treatment plants do not remove the nitrogen. Nitrogen is the major nutrient in rivers which transport it to coastal marine systems. Based on trends discussed above, the baseline scenario projects an increase of only 3.8% in the flow of nitrogen compounds to coastal marine systems worldwide between 2000 and 2030. This will lead to increasingly severe problems associated with eutrophication in a number of coastal seas. As may be seen in the table below, the projections indicate substantial differences among countries and regions with OECD and other developed countries showing a decrease of 10.2% while developing countries are projected to show an increase of 10.1% with particularly large percentage increases projected for China (16%) and South Asia (42%). Africa, on the other hand, is expected to exhibit a slight reduction due to a slower rate of growth of intensive agriculture combined with soil nutrient depletion.

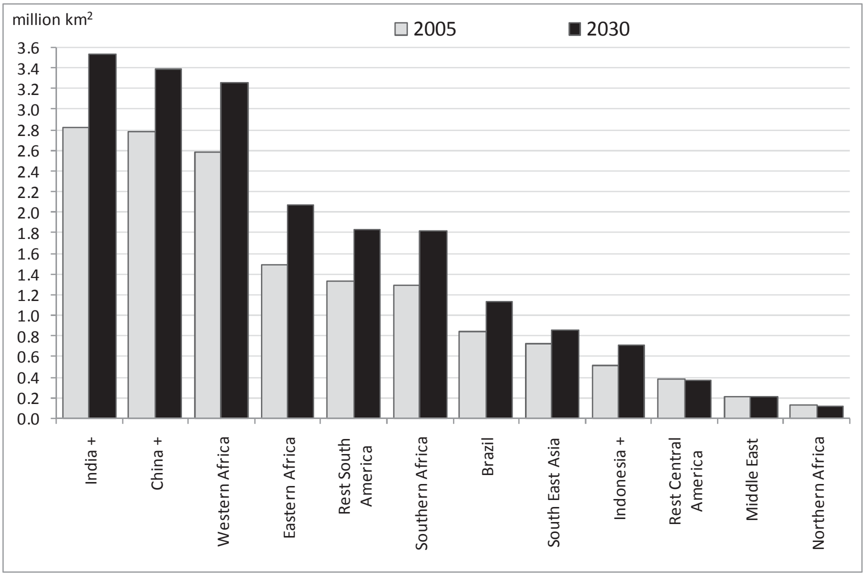
Figure 2.9. River nitrogen transport, 2000 and 2030 (Gg/yr)



Source: Env-Linkages/IMAGE model analysis.

Water-induced soil degradation

Figure 2.10. Land area subject to high erosion risk by major region, 2005 and 2030

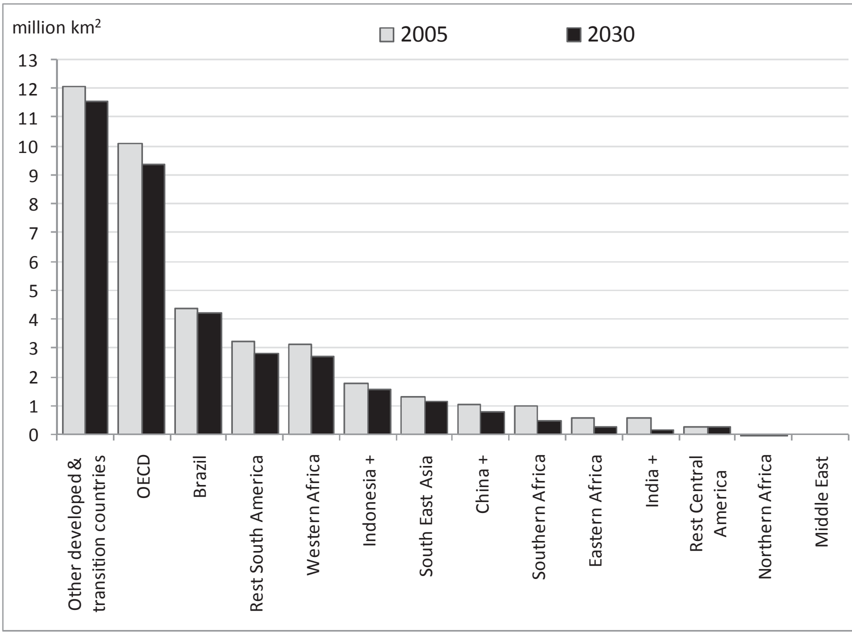


Source: Env-Linkages/IMAGE model analysis.

Water-induced soil degradation is projected to worsen as a result of an increase in the amount of land area characterised as subject to high levels of erosion risk. Worldwide an increase from 21.5 to 26.7 million sq km of land at risk from soil erosion is projected between 2005 and 2030. In developing counties, the area subject to such risk is projected to increase by 28% between 2005 and 2030 with the largest absolute increases projected to occur in Africa, especially eastern Africa (39%), and southern Africa (42%) as may be seen from Figure 2.10. Important increases are also projected for Brazil (35%), India and other South Asia (25%), and other Latin America (37%). This highlights the need for increased soil conservation measures like contour ploughing and terracing which can reduce the risk.

Deforestation and terrestrial biodiversity

Figure 2.11. Natural forest area remaining, 2005 and 2030 (Ha)

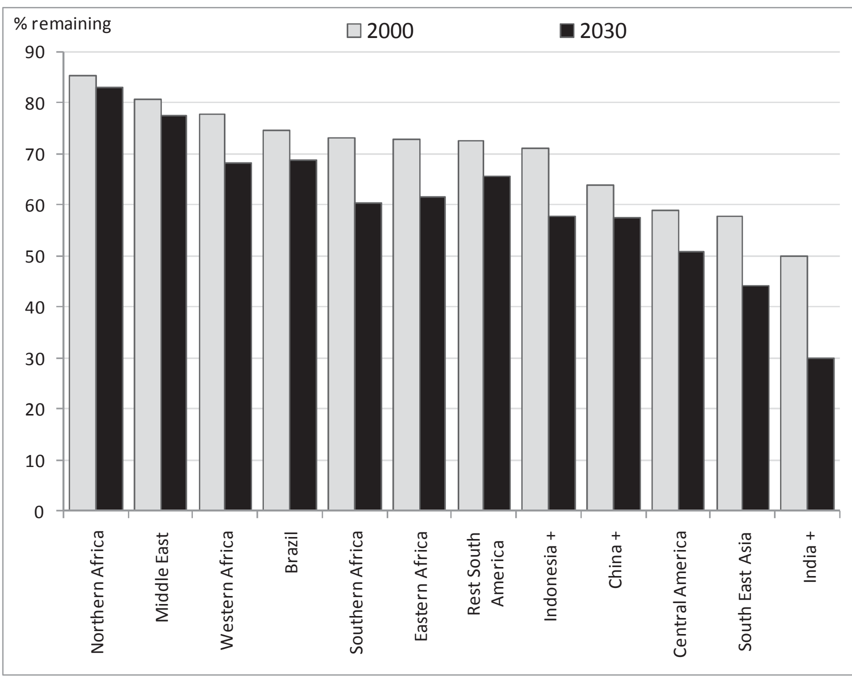


Source: Env-Linkages/IMAGE model analysis.

This section describes projected changes in the areas of natural forest, excluding re-growth between 2005 and 2030. The projections have been based on projections of agricultural land expansion and abandonment and on demand for industrial roundwood. The projections also take into account the expansion of plantations which are expected to meet a large and growing fraction of the incremental demand for wood and pulp. Calculations do not include re-growth after clear-cutting in the scenario period. Natural forests are projected to decline in nearly all regions and large countries and to decrease worldwide by 10.6%. In absolute terms most of the loss is projected to be in developing countries where the decline is projected to be 16.7%, with proportionately large declines in South Asia (71%), western Africa (13%), eastern Africa (57%), southern Africa (51%) and other Latin America (12%). Declines are projected to be proportionately smaller in Brazil, Russia and transition economies, China, and OECD countries.

Projected changes in terrestrial biodiversity are measured with the indicator, mean species abundance (MSA), defined as the change of selected species relative to the undisturbed natural situation.[2] Changes in the MSA have been modelled as resulting from loss of habitat, annual mean temperature change, excess nitrogen deposition, infrastructure and fragmentation. Changes in MSA are quite large for many developing country regions as can be seen in the figure below which shows developing countries arrayed in descending order of biodiversity richness projected in 2030. Reductions in biodiversity are projected to be particularly large in Central and South America, in sub-Saharan African regions, and in Asian regions apart from China.

Figure 2.12. Biodiversity in developing countries, 2000 and 2030 (percentage remaining)

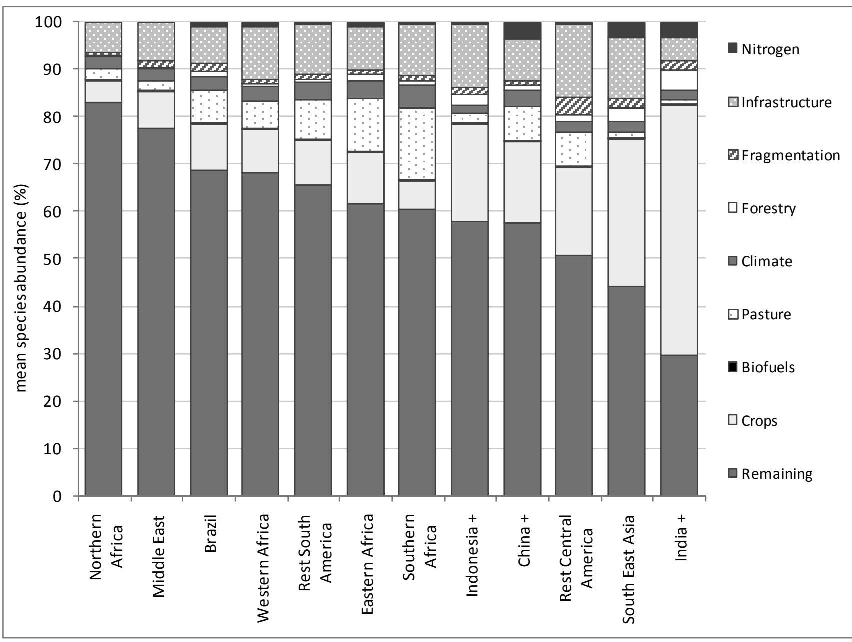


Source: Env-Linkages/IMAGE model analysis.

2 . Mean species abundance (MSA) captures the degree to which biodiversity, at a macrobiotic scale, remains unchanged. If the indicator is 100%, the biodiversity is similar to the natural or largely unaffected state. In this case, the MSA is calculated on the basis of the impacts of human activities on "biomes". A reduction in MSA, therefore, is less an exact count of species lost, than an indicator that pressures have increased.

The major cause of habitat loss projected for 2030 is conversion of natural land to agriculture; next in importance is infrastructure expansion which is driven by GDP growth; fragmentation which results from both agricultural expansion and infrastructure development is also important as can be seen in Figure 2.13 below. In a few regions, especially Indonesia and South Asia, forest clearing is projected to be important; excess nitrogen loading is projected to be important in China and the rest of East and South East Asia.

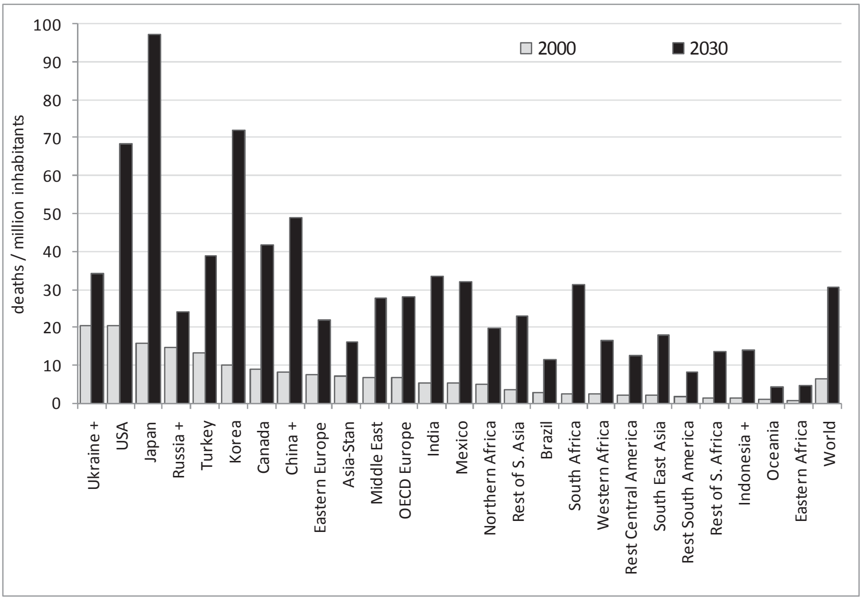
Figure 2.13. Pressures on remaining biodiversity, 2030 (percentages)



Source: Env-Linkages/IMAGE model analysis.

Human health impacts

Figure 2.14. Ozone related mortality in the urban population, 2005 and 2030 (deaths/million inhabitants)

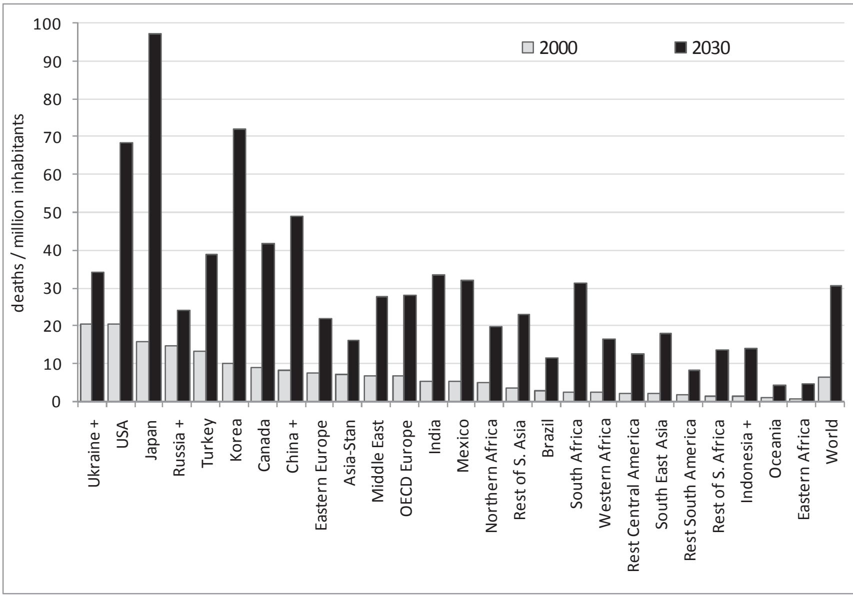


Source: Env-Linkages/IMAGE model analysis.

The impacts of environmental change on human health are mainly due to water-borne diseases related to unmet sanitation needs and to respiratory disease and asthma due to air pollution. As may be seen in Figure 2.14, the incidence of death due to exposure to ozone in urban areas is expected to worsen in all countries and regions, developed and developing alike between 2005 and 2030. The situation is expected to be similar to the situation in most OECD countries by 2030 for many developing countries and regions (northern, western, and southern Africa, Middle East, Indonesia, and other Southeast Asia), but it is expected to be substantially worse in India and other South Asia.

However, on a country-wide basis the mortality rates in most developing countries due to ozone exposure are projected to remain substantially lower than in OECD countries because rates of urbanisation are substantially lower even by 2030. In China, however, the mortality rate in 2030 is expected to exceed that in most OECD countries.

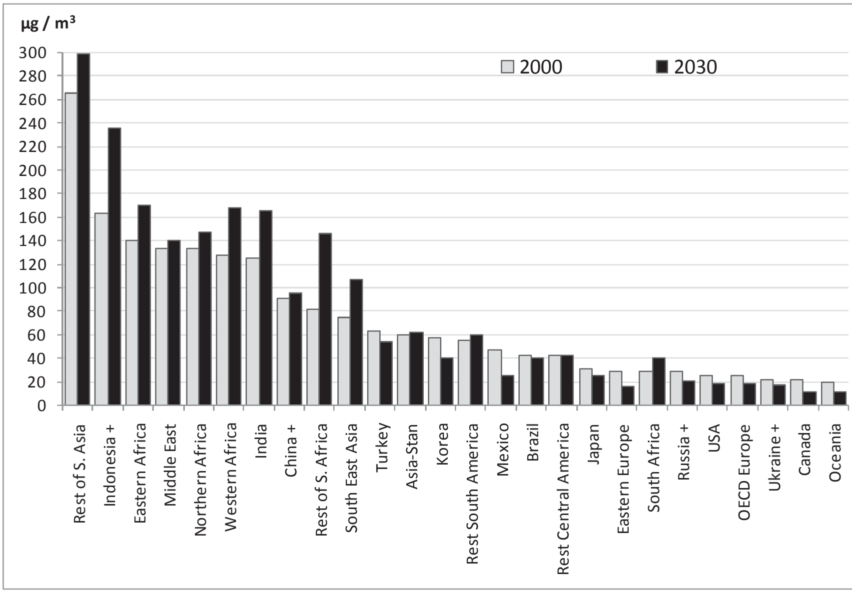
Figure 2.15. Ozone related mortality in the total population, 2000 and 2030 (deaths/million inhabitants)



Source: Env-Linkages/IMAGE model analysis.

Unlike the case of ozone which is mainly due to combustion of fossil fuels in transport, particulate matter can come from a variety of sources, including dust. Figure 2.16 shows that in 2005 concentrations of small particulate matter (PM_{10}) were already a great deal higher than in OECD countries in all African regions except South Africa, the Middle East, India, other South Asia, China, Indonesia, and other East and Southeast Asia. In Latin America countries they were only slightly higher than in OECD countries. Between 2005 and 2030, the concentrations of particulate matter are projected to fall in OECD countries and remain roughly stable in Latin America, but to increase in all other developing country regions.

Figure 2.16. Concentrations of particulate matter (PM_{10}) in world regions, 2000 and 2030 (Microg/M3)



Source: Env-Linkages/IMAGE model analysis.

Acronyms

BRIC	Brazil, Russia, India and China
BRIICS	Brazil, Russia, India, Indonesia, China and South Africa
CBD	Convention on Biological Diversity
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CSD	Commission on Sustainable Development
DAC	OECD Development Assistance Committee
EJ	Exajoules
EO	Environmental Outlook
EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
EU-25	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
EUR	Euro (currency of European Union)
FAO	Food and Agriculture Organisation of the United Nations
GBP	Pound sterling
GDP	Gross domestic product

GHG	Greenhouse gas
GJ	Gigajoules
GNI	Gross national income
Gt	Giga tonnes
GTAP	Global Trade Analyses Project
GW	Gigawatt
IEA	International Energy Agency
IMAGE	Integrated Model to Assess the Global Environment
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MAD	Mutual Acceptance of Data
MDGs	Millennium Development Goals
MEA	Multilateral environmental agreement
MNP	Netherlands Environmental Assessment Agency
MSA	Mean species abundance
Mt	Million tonnes
MWh	Megawatt-hour
PFC	Perfluorocarbon
PM	Particulate matter
$PM_{2.5}$	Particulate matter, particles of 2.5 micrometres (µm) or less
PM_{10}	Particulate matter, particles of 10 micrometres (µm) or less
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million by volume
PPPs	Purchasing Power Parities
ROW	Rest of world
RTA	Regional trade agreement

UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VOC	Volatile organic compound
WHO	World Health Organization
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

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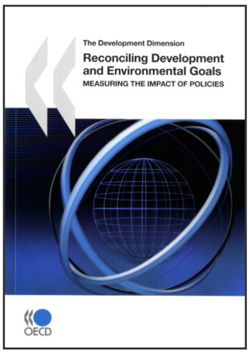

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