THE EUROPEAN ENVIRONMENT

STATE AND OUTLOOK 2010

ASSESSMENT OF GLOBAL MEGATRENDS

European Environment Agency


SOER
2010

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Call for evidence on global megatrends

EEA would like to thank all institutions and experts who responded to the related call for evidence to support the European Environment Agency (July–September 2009); they helped shape this work in its early stages.

Contents

Foreword

Everyone opening this report, *The European environment — state and outlook 2010: assessment of global megatrends*, should bear in mind a proviso: it requires some hard work from its readers. Rather than being prescriptive, this study aims to prompt questions, such as:

- How can we avoid urgent and critical global feedbacks in resource-using systems when we are very far from understanding them completely?
- To what extent should we invoke the precautionary principle given our limited knowledge of environmental risks?
- How should we ensure that lack of knowledge does not become a reason for inaction?

The report covers a broad range of topics, setting out trends that are likely to influence and shape Europe's future, and their possible environmental implications. It clusters megatrends into five groups — social, technological, economic, environmental and political — while stressing the numerous interdependencies.

The focus is not on what will be making headlines tomorrow, or even in the next few years, although much of its content may be headline news in 2030. And it is not a checklist of either imminent or distant crises. The megatrends described in this report may have far-reaching, critical consequences but they may also represent opportunities. The end result will depend on the choices we make today, tomorrow and on the days that follow.

Two other fundamental themes are **knowledge** and **uncertainty**. Our knowledge is incomplete, introducing uncertainty into projections. And as uncertainty grows, even broad measures of probability become increasingly elusive.

The uncertainties and complexity of highly interdependent, interconnected human and natural systems suggest that our existing forecasting methods are increasingly inadequate. To face the multiple systemic challenges before us, we urgently need a better understanding of uncertainty itself and of how projections are made.

This report asks many questions, it implies others, and it will probably trigger still more as you make the myriad connections it demands. There is one absolute certainty, however: business as usual simply will not be sufficient to face the challenges ahead.

What is the SOER 2010?

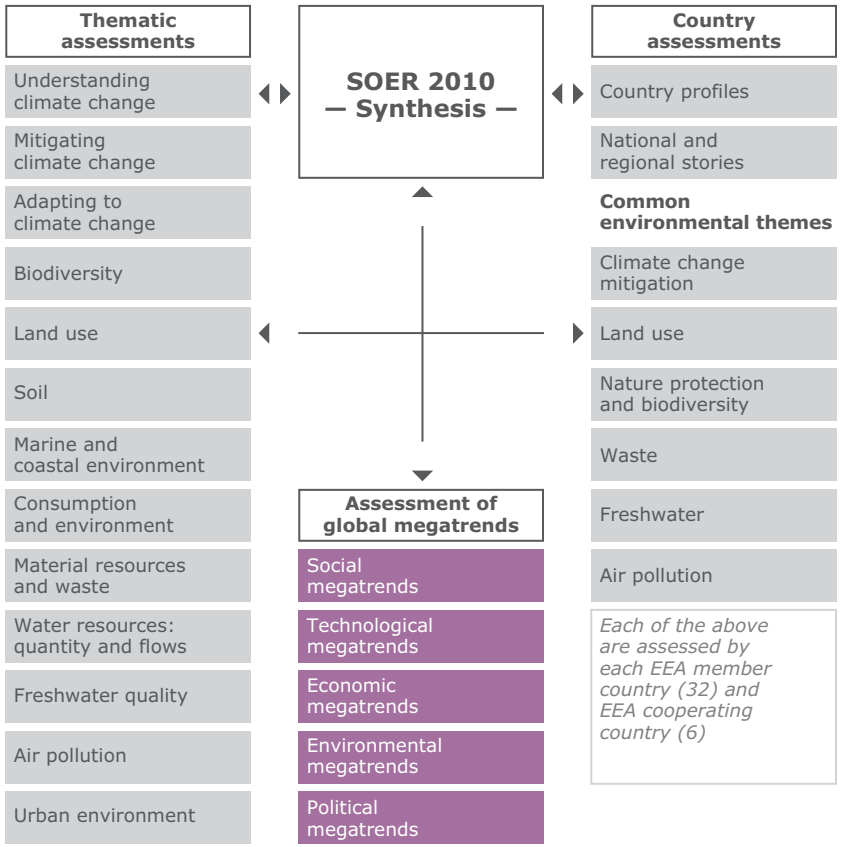
This 'assessment of global megatrends' is part of *The European environment — state and outlook 2010* (SOER 2010).

SOER 2010 is aimed primarily at policymakers, in Europe and beyond, involved with framing and implementing policies that could improve Europe's environment. The information can also help European citizens to better understand, care for and improve their environment.

The SOER 2010 'umbrella' includes four key assessments:

- this exploratory assessment of **global megatrends** relevant for the European environment;
- a set of 13 Europe-wide **thematic assessments** of key environmental themes;
- a set of 38 **country assessments** of the environmental situation in individual European countries;
- a **synthesis** — an integrated assessment based on the above assessments and other EEA activities.

SOER 2010 assessments



All SOER 2010 outputs are available on the SOER 2010 website: www.eea.europa.eu/soer. The website also provides key facts and messages, summaries in non-technical language and audio-visuals, as well as media, launch and event information.

Why assess global megatrends?

Europe is bound to the rest of the world through an enormous number of systems — environmental, economic, social, political and others — enabling a two-way flow of materials and ideas. Europe contributes to global environmental pressures and accelerating feedbacks through its dependence on fossil fuels, mining products and other imports. Conversely, changes elsewhere increasingly affect Europe, both directly as in the case of environmental change or indirectly through, for example, intensified socio-economic pressures.

This assessment of global megatrends focuses on the impact of global pressures on Europe. A global-to-European perspective is relevant for European environmental policymaking because Europe's environmental challenges and management options are being reshaped by global drivers such as demographics, technologies, trade patterns and consumption.

Many of these changes are interdependent and likely to unfold over decades. They can significantly affect Europe's resilience in the long term. Naturally, such changes also offer unique opportunities for action. But effective measures require better information and better understanding of a highly complex and evolving situation.

The present assessment groups a rich diversity of information on global drivers of change into a number of identified social, technological, economic, environmental and political (governance) megatrends. It summarises key developments succinctly and attempts to trigger a discussion about how we should monitor and assess future changes in order to better inform European environmental policymaking.

There are many ways to assess global megatrends and a number of diverging views are valid. The diversity, complexity and uncertainty inherent in the analysis require a broad, diverse approach to building up the information base, including stakeholder consultation and the use of existing academic and other expert information.

The approach used for this assessment has included:

- A public call for evidence on global megatrends of relevance for Europe's long-term environmental context. The call was launched in June 2009 via the EEA website and disseminated to relevant research networks and mailing lists. It generated a list of relevant studies that helped further prioritise topics for the analysis.

- Setting up an external advisory group to guide the progress of the work, comprising representatives of international and national organisations in the field of environmental assessment as well as the EEA's Scientific Committee members.

- Reviews of academic and non-academic information sources in the form of eight targeted background reports produced between autumn 2009 and 2010.

- Consolidating the information base following the STEEP (social, technological, economic, environmental and political) framework for classifying drivers of change.

- Structuring the information base into information sheets including indicators.

The complexity of interlinkages and the manifold uncertainties inherent in megatrends require an exploratory, qualitative approach, underpinned by empirical data. This does not rely solely on quantitative modelling, although model results are used in the analysis. Current approaches to risk analysis and quantitative forecasting are problematic since the systems addressed and their dynamics are not well understood, assumptions are often non-transparent, and necessary data are not always available.

Subsequent chapters of this report analyse the 11 most relevant megatrends, summarising the links with Europe's priority environmental challenges and possible implications for policymaking.

1 Increasing global divergence in population trends

The global population will still be growing midway through the 21st century but at a slower rate than in the past. People will live longer, be better educated and migrate more. Some populations will increase as others shrink. Migration is only one of the unpredictable prospects for Europe and the world.

The main demographic characteristics of this century are expected to be:

- ageing of societies, which will spread to most countries;
- slower global population growth, with major regional differences;
- migration, especially caused by environmental factors.

Today the world population is continuing to grow, although much more slowly than in the recent past. It has more than doubled since the 1960s but is very unlikely to double again during the current century (IIASA, 2007). Instead, it is expected to peak at approximately nine billion by around 2050 (UN Population Division, 2009) or 2070 (IIASA, 2007). There is a less than 10 % chance that in 2100 there will be fewer people than today, or that the total will exceed 11 billion (Lutz et al., 2008).

Considerable differences exist, however, in terms of projected regional population growth. A major decline is forecast in eastern Europe ([1]), where the population is expected to be less than half today's level by 2100. Contrastingly, in many African countries the population is likely to have doubled by 2100 (IIASA, 2007).

([1]) The IIASA grouping for eastern Europe comprises Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Hungary, Moldova, Montenegro, Poland, Romania, Serbia, the Slovak Republic, Slovenia, Russia and Ukraine.

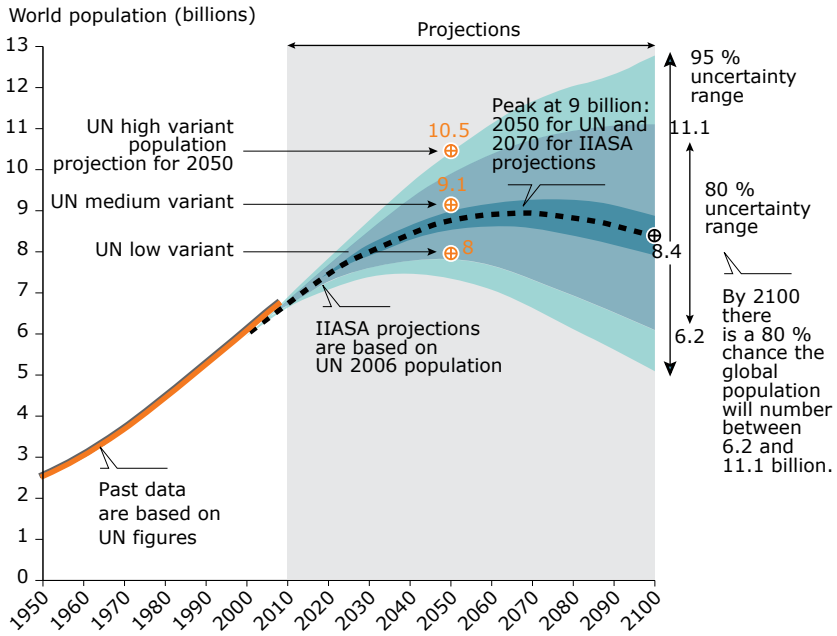
From 2020–2030 onwards, declining populations are also expected in some developing countries, especially in Asia. Most of the countries of North America and western Europe ([2]) are still growing despite ageing, mostly due to migration ([3]). However, it is expected that they will also register declines if policies are not introduced to compensate for the impacts of advanced ageing, for example measures to attract migrants.

China can expect a dramatic demographic transformation with a massive shift in age structure. China's population is projected to start declining around 2030 and the working age population, which currently provides one of the biggest drivers of economic growth, will decline rapidly both in absolute terms and as a proportion of the total population. After initially increasing, by mid-century China's population will have fallen to its size in 2000 and by the end of the century it may have halved from the 2000 level. China's trends are qualified, however, by considerable uncertainty over expected fertility rates, gender balance (the relative number of baby girls born is declining due to the one-child policy), the population's age structure and the current size of the population (IIASA, 2007).

([2]) The IIASA grouping for western Europe comprises Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Greenland, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

([3]) In developed countries, immigrants accounted for nearly half of the population growth rate in the 1990s (IIASA, 2008, 2009).

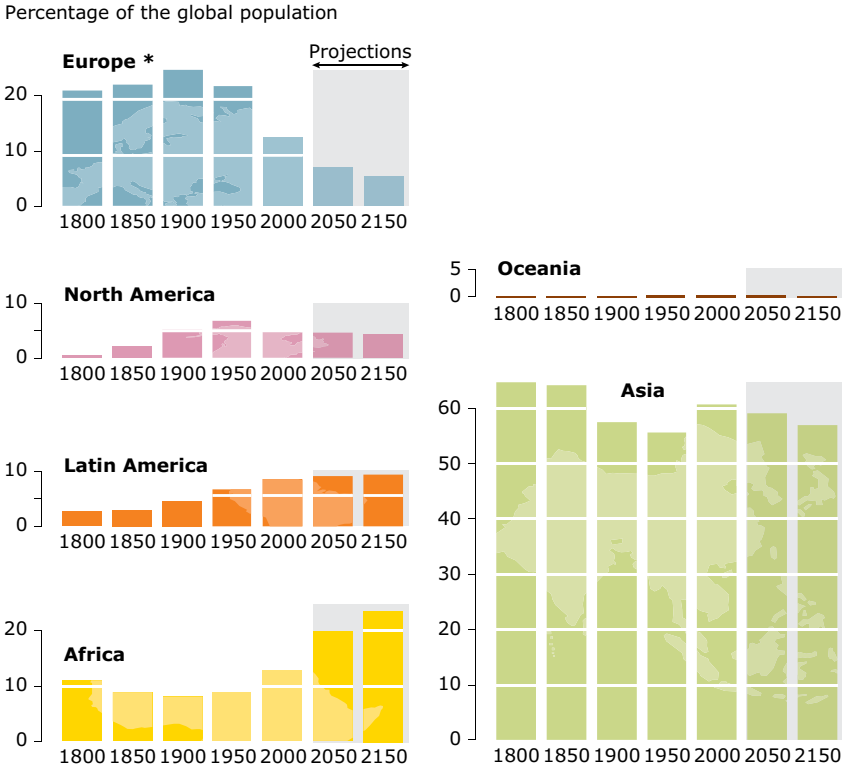
Figure 1.1 World population projections



Note: The UN Population Division studies fertility-evolution scenarios to produce high-, medium- and low-variant figures, whereas IIASA bases its calculations on assumptions for fertility, mortality and migration (with the latter only affecting regional projections).

Source: IIASA, 2007; UN Population Division, 2009.

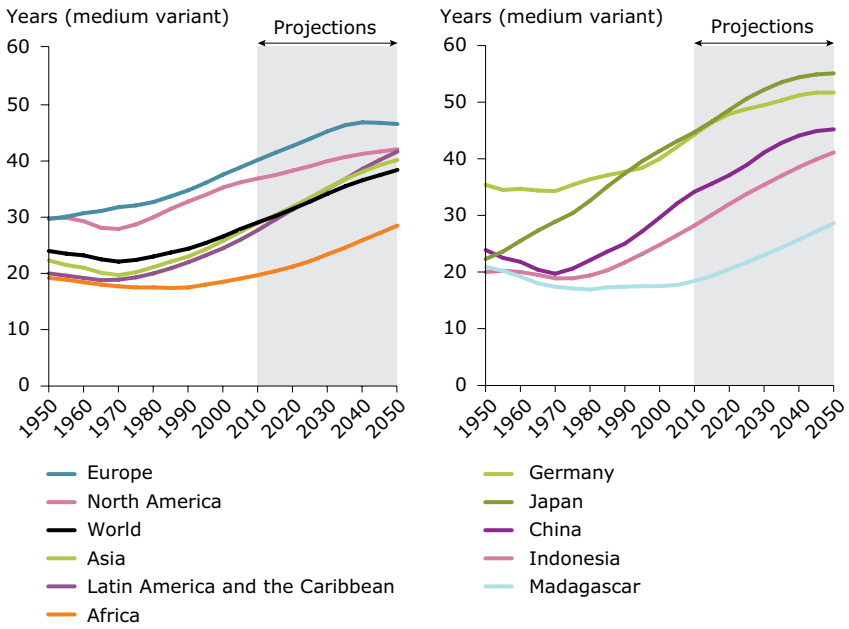
Figure 1.2 Regional shares of the global population



Note: * In its geographical definition (including Russia up to the Ural Mountains).

Source: UN Population Division, 1999; Le Monde Diplomatique, 2009.

Figure 1.3 Median age projections: selected regions and countries



Note: Median age is the age that divides a population into two numerically equal groups: half the people are younger and half are older.

Source: UN Population Division, 2009.

Demographers expect the average age of populations to rise throughout this century. Particularly rapid increases are foreseen in the next few decades, especially in some developing countries (notably China, some Pacific islands and central Asian states). From about 2030 to 2050, this trend will spread to most regions of the world (Lutz et al., 2008; NIC, 2008).

There are obvious differences between developed and developing countries in terms of the speed of ageing. By 2050, developing countries are expected to be ageing as fast as the developed world is now (Jackson and Howe, 2008). Developing countries will have less time to adapt than developed countries and face challenges in addressing changes in the structure of society with limited resources.

One significant impact of ageing is on the size of the working population. It has already peaked in developed countries and is expected to peak in around 2015 in China (Lutz, 2009; CIA, 2001). The oldest in society are also more vulnerable to disease and climate change impacts, placing new demands on society (CIA, 2001; DG ECFIN, 2009).

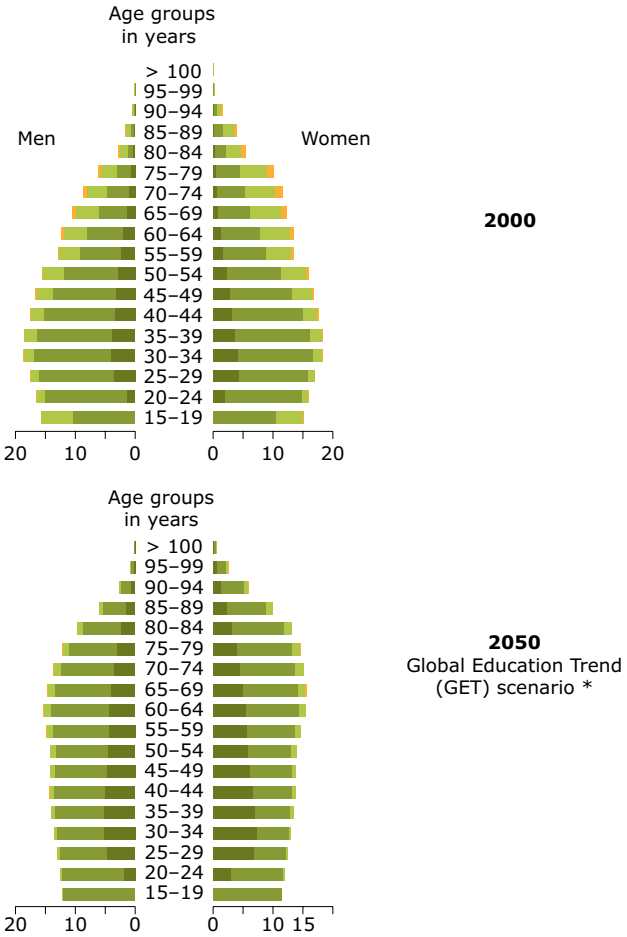
In contrast to the marked ageing of many developed world populations, many developing country populations will have substantial 'youth bulges' (disproportionate concentrations of people in the 15–29 year-old age group) until 2025. Several of the countries with the largest bulges are located in in sub-Saharan Africa and the Middle East and are among the world's most unstable (or potentially unstable) states. Figures 1.4a and 1.4b illustrate among others the growing disparity between the age structure of the European Union and Africa.

These demographic differences, combined with growing economic disparities, are increasing the pressure for migration, which is expected to become a more important factor in demographic change over the next 50 years. Environmentally induced migration will gain in importance (see Map 3.1). Migration significantly affects ethnic diversity, age composition and the size of the workforce in recipient countries.

While there is reasonable confidence over broad trends in the shorter term, substantial uncertainty attaches to the specific trend for any country or region (NRC, 2001).

Figure 1.4a Population pyramids for 2000 and 2050 — European Union

Population by age, sex and educational attainment



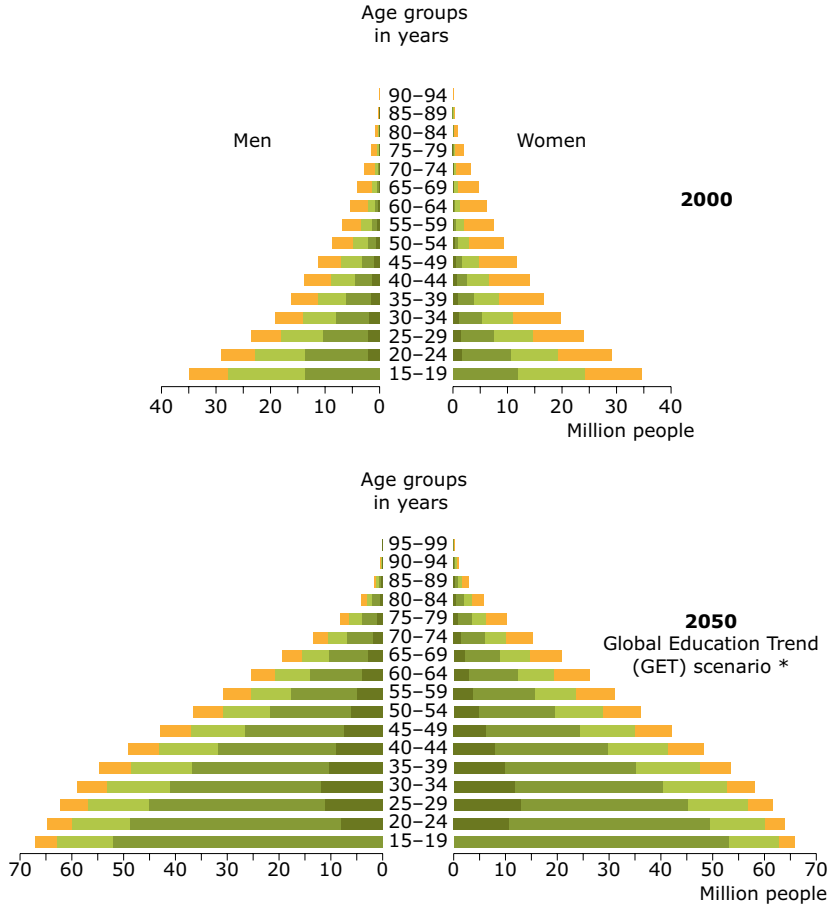
Educational attainment: Higher education; Secondary education; Some primary education; No formal education

Note: * The GET scenario is not derived from a simple assumption. It is based on the country's educational expansion of historical trend.

Source: Samir et al., 2010.

Figure 1.4b Population pyramids for 2000 and 2050 — Africa

Population by age, sex and educational attainment

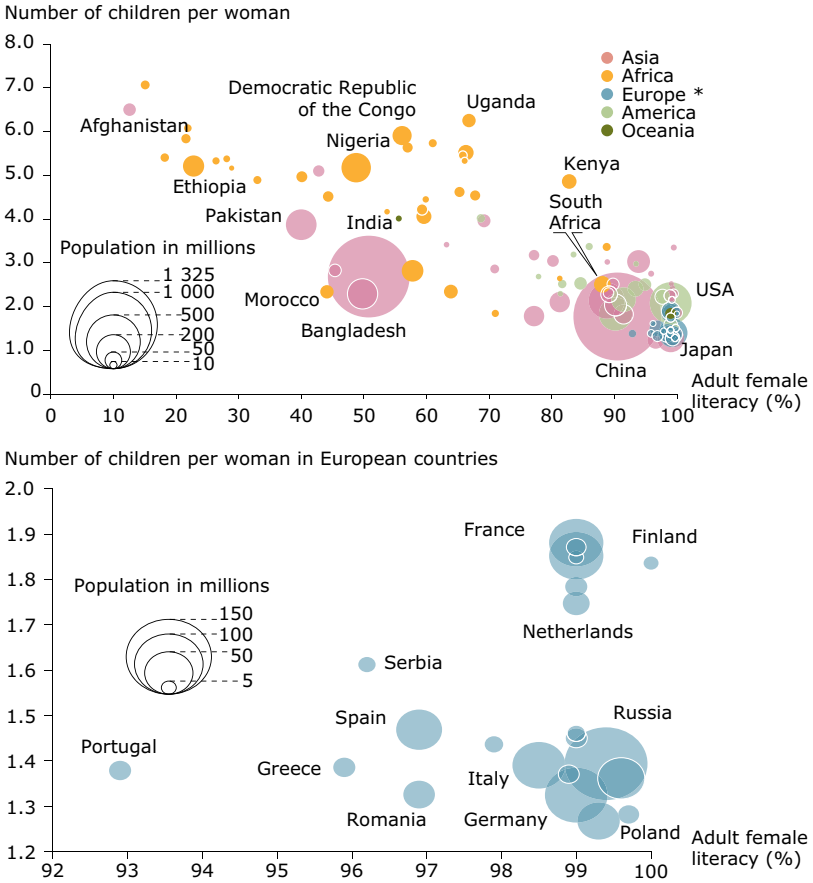


Educational attainment: Higher education; Secondary education; Some primary education; No formal education

Note: * The GET scenario is not derived from a simple assumption. It is based on the country's educational expansion of historical trend.

Source: Samir et al., 2010.

Figure 1.5 Correlation between fertility and female education



Note: Adult literacy rate is the percentage of people aged 15 and above who can, with understanding, read and write a short, simple statement on their everyday life.

Please note the scale difference between the two graphics.

* The European countries considered here are: Belarus, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Poland, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, the Netherlands, Ukraine, the United Kingdom.
Data: 2000 to 2009.

Source: UNESCO, 2010; World Bank, 2010; UN Population Division, 2009; Gapminder, 2010.

After 1950, migration was driven by the liberalisation of trade in goods and by movements of capital, and was further accelerated by differences in income and by conflict. Migration can benefit both host countries, for example by filling a labour gap, and home countries through remittances. Migrations are complex and uncertain phenomena which depend on a range of undefined social, economic and environmental factors. There is currently no way to consider these uncertainties in projections.

From a development perspective, what matters is not simply the number of people in a country but also the population's productive potential or human capital (DRC, 2008). The shifting distribution of human capital (quantified in terms of the people of working age with at least a secondary education) differs from the main demographic trends. Europe and North America possess the most human capital today but in the future Asia is expected to show the biggest gains, with Africa remaining at the bottom. By around 2015 China's human capital will overtake Europe's and North America's combined (Poncet, 2006).

Box 1.1 Why is demography important for Europe?

Population growth influences most global megatrends. The anticipated end of population growth during the current century will not solve the world's problems but can help efforts towards sustainable development.

A growing population normally increases natural resource use and environmental pollution, and causes land use changes like urbanisation. Shifts in global demographic trends will have indirect impacts on the European environment through climate change and resource consumption. Migration into Europe may partially compensate for the natural decline of Europe's population and workforce, but ensuring that it occurs will require substantial policy interventions at a regional and national level (Nimwegen and Erf, 2010).

Pearce (2010) has questioned that notion that overpopulation itself threatens planetary crisis. It is not that there are too many of us for the planet to sustain but that we are collectively using up more resources than the planet can produce. The use of natural resources is driven more by economic growth than population growth in a growing number of regions.

Key drivers and uncertainties

Fertility, mortality, migration, economic development, poverty and governance are the main drivers of population growth. Uncertainty abounds, however, for example with respect to migration flows, female education and access to birth control, fertility rates, access to health care and life expectancy (NIC, 2008). How will government policies on education, health, migration and urbanisation develop? How will technology improve the lives of elderly people? There is even uncertainty over our current situation, including fertility levels in China and HIV/AIDS prevalence in Africa (IIASA, 2007).

The development of fertility rates in different parts of the world is uncertain, especially after the transition to older societies in developed countries. Half the world already has a fertility rate below the long-term replacement level. That includes all of Europe, and much of the Caribbean and the far East. Even small changes in fertility rates can lead to significant changes in population sizes. Globally, women today have half as many babies as their mothers did, mostly from choice. The average age at which women have children influences population dynamics. In addition, Figure 1.5 illustrates the clear correlation between fertility rates and levels of female education.

Concerning mortality, demographers have historically tended to underestimate gains in life expectancy, which has affected population ageing predictions. New approaches and alternative indicators are being developed to take into account the effect of longer, healthier lives. Uncertainties regarding life expectancy relate to the biological upper limit of the human lifespan (particularly in developed countries) and to the efficiency of local health services (especially in developing countries). Uncertainties also exist regarding how far the positive effects of longer, healthier lives will be cancelled out by other trends such as increased inequalities, decreasing health of poor people and the spread of diseases. The links between ageing and economic growth are now better understood, however, showing that ageing's costs to society may be less than predicted earlier (Pearce, 2010).

Life expectancy rose rapidly in the 20th century, thanks to improvements in public health, nutrition and medicine. It is expected to increase further (Figure 1.3), supported by technology and economic development and access to health care, although the

associated costs could restrict many of the benefits to the wealthiest in society. Access to health care, clean drinking water, sanitation, family planning services, healthy food and advanced treatment varies and could cause increasing health gaps between rich and poor. These inequalities exist between regions but also within countries and cities, especially in emerging economies (EEA, 2010a).

Poverty is a key driver of migration, which is considered the most uncertain driver of population growth (IIASA, 2007). Economic growth, environmental degradation, climate change impacts and migration policies are the main uncertainties influencing international migration flows.

The increasing uncertainties and complexity in projected demographic trends suggest that existing population forecasting methods are inadequate. With this in mind, it is important that decision-makers relying on scenario studies gain a better understanding of uncertainty and the way that projections are made (Lutz, 2009). To achieve that, uncertainties and assumptions on which projections are based need to be communicated better to users (IIASA, 2007).

2 Living in an urban world

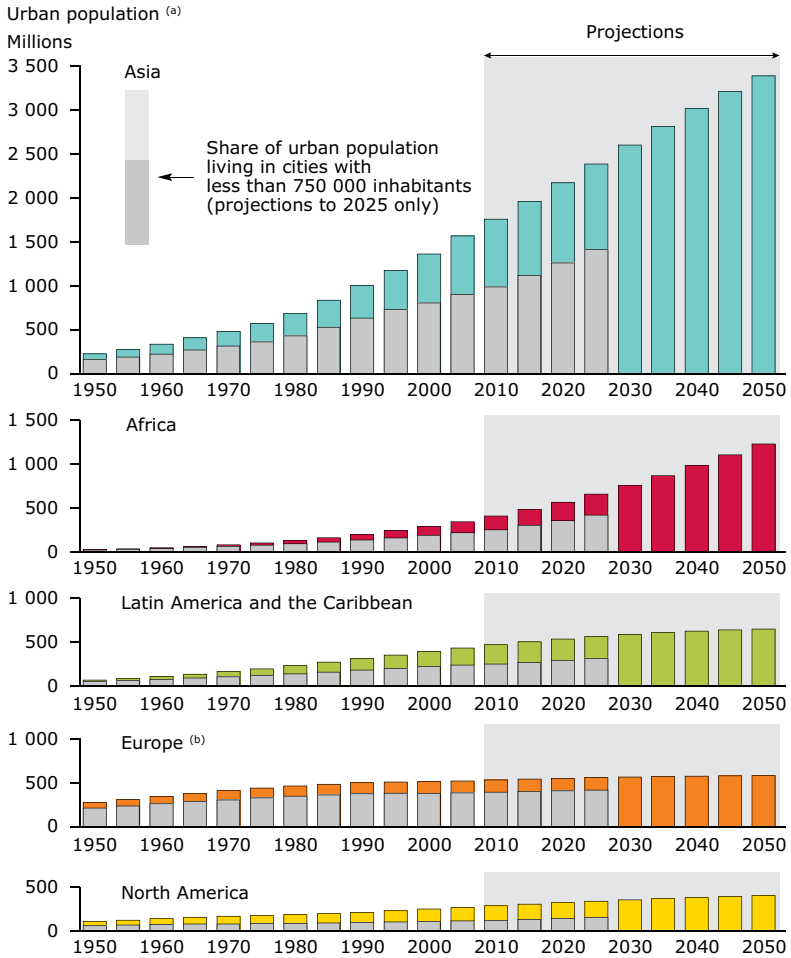
An increasingly urban world will probably mean spiralling consumption and greater affluence for many. But it also means greater poverty for the urban underprivileged. Poor urban living conditions and associated environmental and health risks could impact all areas of the world, including Europe.

For the first time in history more than 50 % of the world's population live in urban areas. By 2050, about 70 % of people are likely to be city dwellers, compared with less than 30 % in 1950 (UN Population Division, 2010).

Demographers estimate that Asia will be home to more than 50 % of the global urban population by 2050, while Europe's urban population as a percentage of the global total is likely to have shrunk considerably. Although many emerging and developing economies may not have reached the same level of urbanisation as today's developed countries by 2050, the speed and scope of the urban transition in the developed world is far greater today than it was just half a century ago (UN Population Division, 2010). Cities are also reaching unprecedented sizes and the rising number of megacities across the globe, putting enormous strain on their natural resource support systems. But the even faster growth in small- and medium-sized cities could be more important from an environmental perspective.

Cities concentrate investment and employment opportunities, promoting economic growth and increasing productivity. They provide higher-income jobs, as well as greater access to goods, services and facilities, bringing improved health, literacy and quality of life. These conditions tempt rural residents to search for a better life and higher income in urban areas. People in the countryside tend to have lower average incomes and more conservative spending habits (EEA, 2010b).

Figure 2.1 Urban population trends

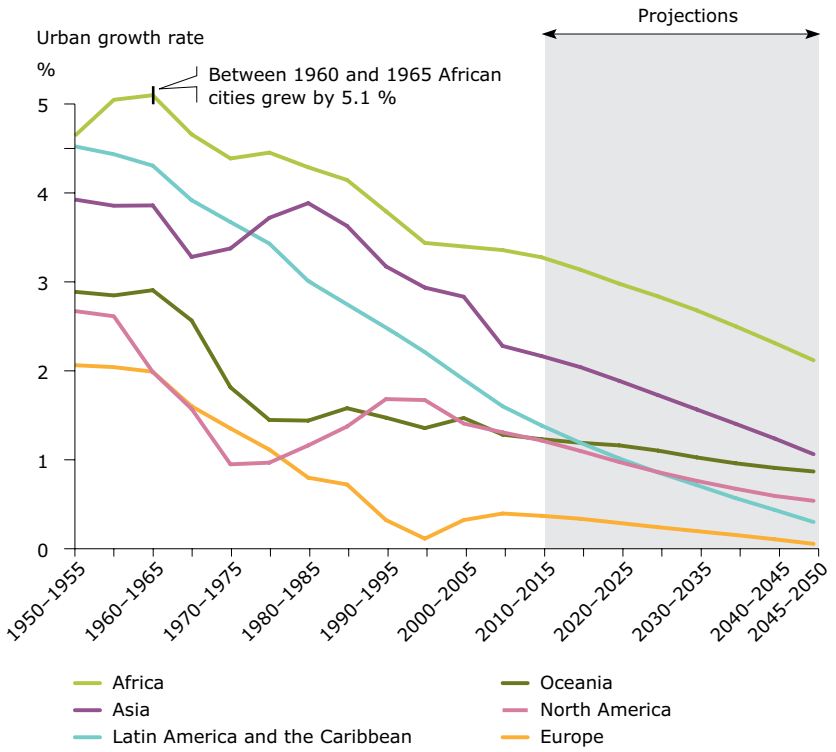


(a) The definiton of 'urban area' varies from one country to the next.

(b) Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Channel Islands, Croatia, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Holy See, Hungary, Iceland, Ireland, Isle of Man, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, the Netherlands, Norway, Poland, Portugal, the former Yugoslav Republic of Macedonia, Moldova, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, the United Kingdom.
Urban areas of Oceania — not included here for legibility reasons — are projected to reach 38 million people by 2050 (currently 25 million).

Source: UN Population Division, 2010.

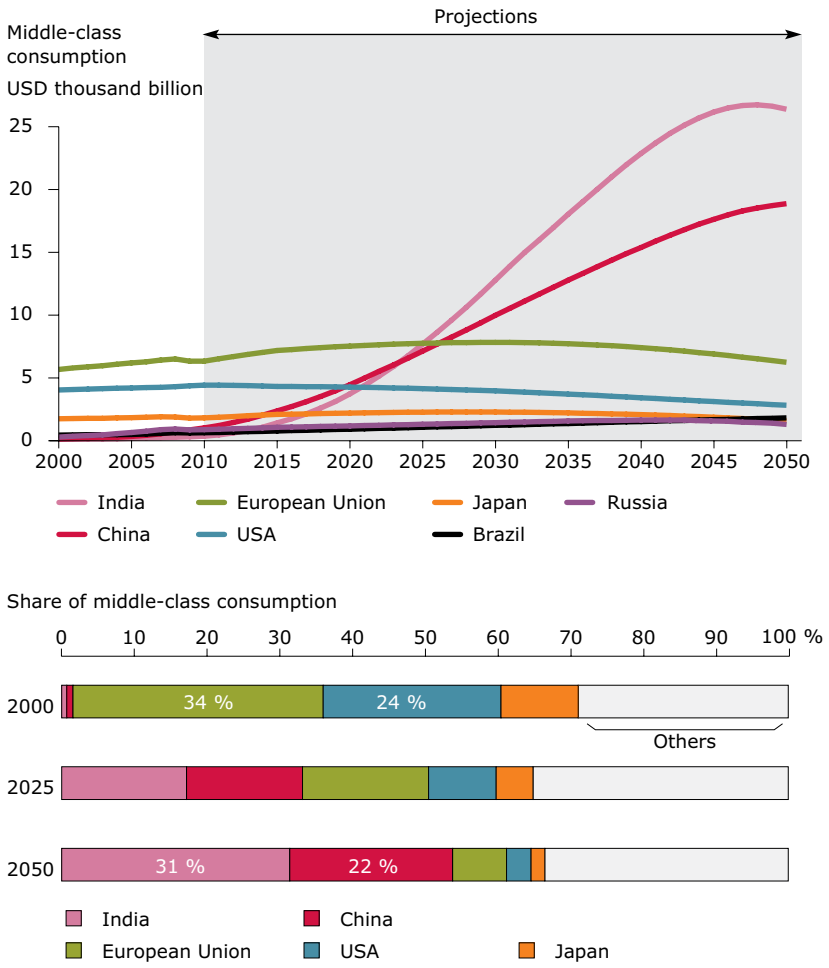
Figure 2.2 Slowing urban growth



Note: 5-year steps.

Source: UN Population Division, 2010.

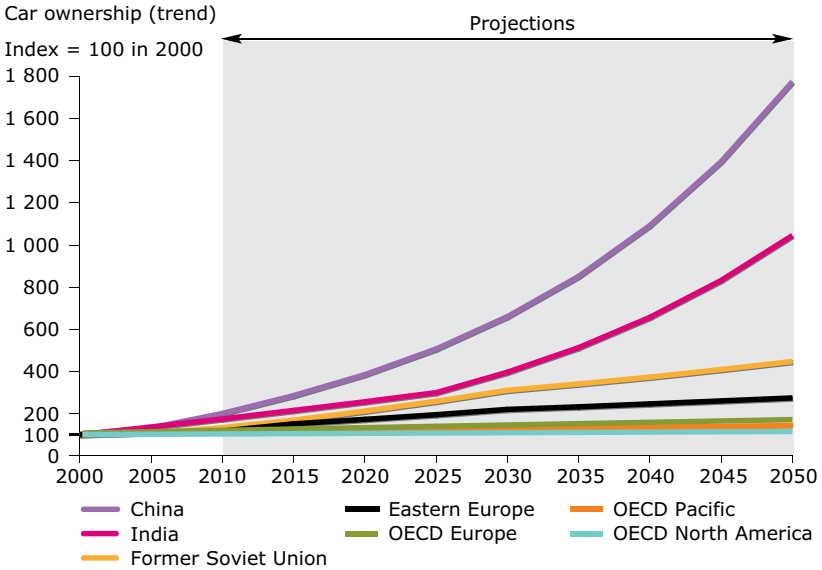
Figure 2.3 Changing consumer spendings of the middle class

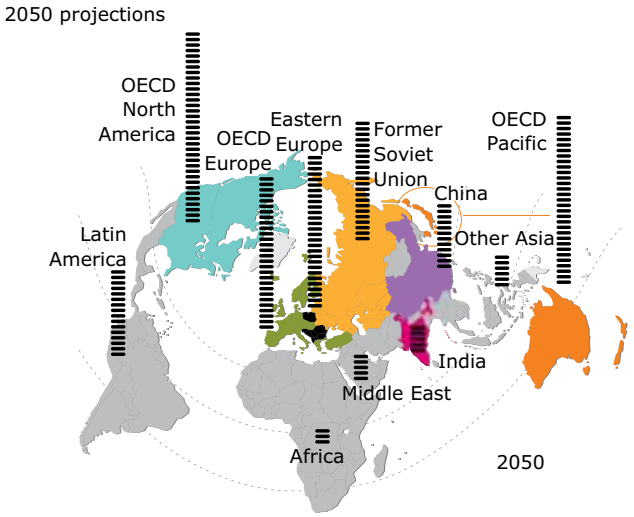


Note: In this study 'middle class' is defined as households with per capita daily spending of between USD 10 and 100 purchasing power parity (PPP).

Source: Kharas, 2010.

Figure 2.4 Projected car ownership





Note: Although car ownership is projected to grow at much higher rates in China and India than in the rest of the world, the number of cars per 1 000 people is projected to stay below that of more advanced economies.

Source: WBCSD, 2004a.

Regional urbanisation levels vary and are very likely to continue doing so. Asia, particularly India and China, is expected to see the bulk of global urban growth and become the dominant world consumer market in the future, followed by countries such as Brazil, Mexico, Russia, South Africa and Turkey. More and more people are now entering the middle class ([4]), increasing average incomes and spending power (Kharas, 2010) (Figure 2.3). According to one estimate the middle class population of South and East Asia, which accounted for about 2.1 % of global income in 2000, could account for more than 7 % by 2030 (World Bank, 2007).

The focus of spending in many emerging economies continues to change from basic to optional goods (Accenture, 2009). By 2025 China is likely to overtake the USA to become the world's biggest consumer market, with India as the third largest and Russia the fourth. These markets will define their own brands, fashions and cultures, increasingly affecting global market developments and trends (NIC, 2008).

Contrastingly, other parts of Asia are struggling to catch up or are even falling behind in terms of overall welfare increases. The processes of urbanisation and changing consumption are also accelerating in other parts of the world but are seldom seen to match the dynamism of the Asian giants.

Urban development offers unique chances for improved quality of life and environmental protection if governed effectively. The concentrated form and efficiencies of scale in cities offer major opportunities to reduce energy demand and minimise pressures on surrounding lands and natural resources. However, urbanisation also threatens the environment by contributing to two contrasting trends: increasing poverty and affluence (Worldwatch Institute, 2008).

In many emerging economies, urban poverty is on the rise. Informal settlements house more than a billion city dwellers already. While the majority of the population suffering severe deprivation still lives in rural areas, there is now a large and growing proportion in urban areas, although official statistics may greatly underestimate the true

([4]) Defined in this study as households with per capita daily spending of between USD 10 and 100 purchasing power parity (PPP).

numbers (Satterthwaite, 2007). Poor planning of housing development often leads to vast settlements at high risk of unhealthy air and water pollution levels, and poorly connected to basic services.

At the same time, economic growth has increased the affluence of a broad section of the urban middle-income population. Globally, urban households are becoming smaller but more energy intensive. Lifestyles increasingly reflect energy- and resource-intensive consumption patterns that produce growing amounts of waste. Expanding transport demands and poor public transport planning encourage car ownership. In the absence of major policy changes, motorised personal vehicle ownership rates are expected to increase significantly (WBCSD, 2004a) (Figure 2.4). One assessment foresees annual sales of highway vehicles in China of 42–59 million by 2050, which is about 10 times the level today (Wang et al., 2006).

Box 2.1 Why is urbanisation important for Europe?

In emerging economies, rapidly increasing numbers of people will demand access to standards of living that have largely been limited to high-income countries. Consequently, demand for international goods and services will grow, along with pressure for policies that support market integration.

How urban areas, particularly in south-east Asia, are built and governed will have strong impacts on global emissions of greenhouse gases and resource demands. Once built, it is difficult and slow to change cities and the individual behaviour adapted to these structures. In many places in the developing world, cities currently run the risk of locking in energy- and resource-intensive models of urban development for decades ahead.

A particular challenge for urban planners in developing countries is the fact that they tend to face multiple environmental problems earlier in the development process (i.e. at lower income levels) than was the case for European countries, for example. Europe can help address these challenges by providing useful expertise and low-carbon and resource-efficient technologies.

Large urban agglomerations (and rural areas) in regions with weak governance structures are vulnerable to social and political unrest, particularly when they are characterised by poor infrastructure and resource supply, and exposed to increased impacts of global environmental change. North Africa and the Middle East have experienced the highest rate of population growth in the world over the past century and could therefore be at risk (UN Population Division, 2010).

In a highly interconnected world, the effects of changes in urbanisation and related consumption patterns on Europe will be mostly indirect. They will include, for example, the possibility of changing European land-use patterns induced by tougher resource competition. If urban slum development continues, the risks of diseases developing and spreading (for example through tourism) may expose Europe to new known and unknown diseases (WHO, 2008b).

Key drivers and uncertainties

Rural-urban migration is driven by several factors: high fertility rates in many rural areas, for example, and limited employment opportunities, particularly from the marginalisation of small farmers. Urban areas offer better jobs and education opportunities. Urban growth is also driven by, among other things, the geographic concentration of investment, including foreign direct investment, and outsourcing from western economies.

A key uncertainty relates to the development of regional fertility rates. If decline does not continue as assumed, urban population growth may strongly exceed current projections. Policy developments, particularly on social welfare and health care, are a key uncertainty and are largely shaped by the prospects for economic growth. The development of domestic consumption also depends on several factors, such as how far economies will integrate economically, the impact of population ageing, and the capacity for strengthening private investment and education.

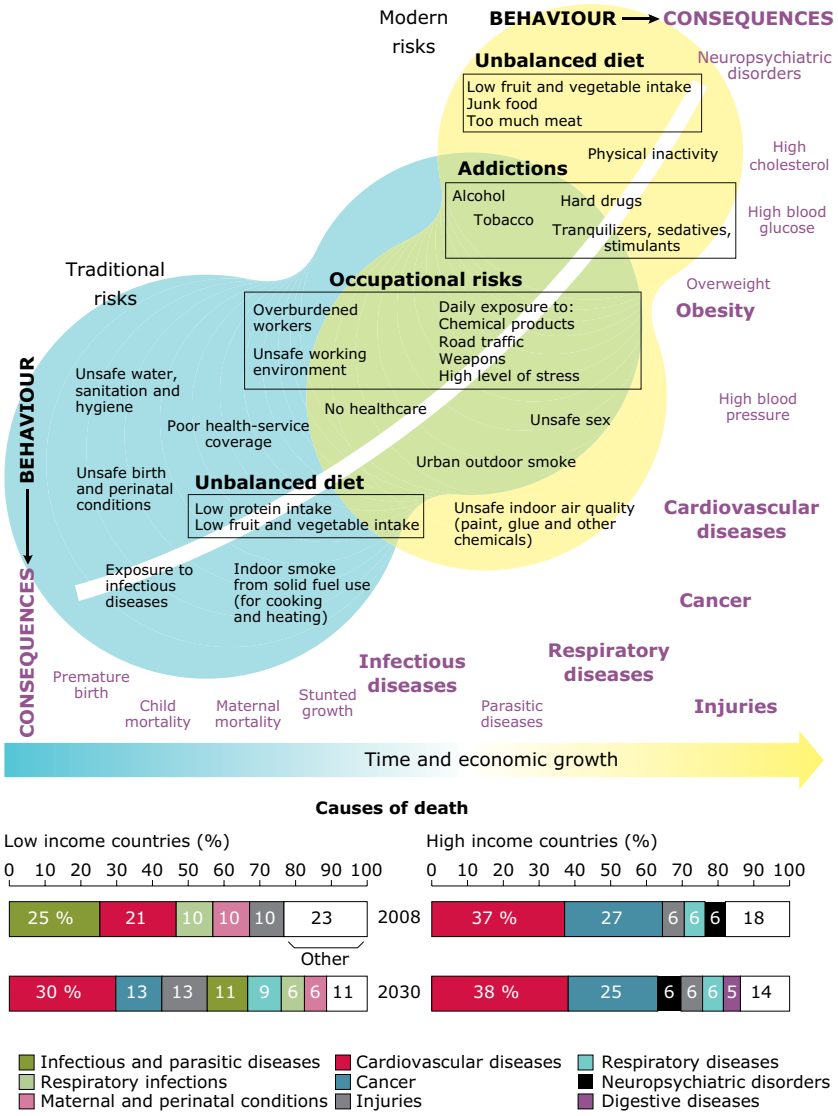
3 Disease burdens and the risk of new pandemics

The risk of exposure to new, emerging and re-emerging diseases, to accidents and new pandemics, grows with increasing mobility of people and goods, climate change and poverty. Vulnerable Europeans could be severely affected.

The disease burden in developed and developing countries differs markedly. Malnutrition and infectious diseases are dominant in the developing world, while obesity and many non-infectious diseases (cardiovascular and neuro-degenerative diseases, diabetes, respiratory diseases, cancer and mental health) predominate in the developed world (WHO, 2006). As countries develop, infectious diseases generally become a less significant part of overall ill health and are replaced by non-infectious diseases (Figure 3.1) often associated with lifestyle, consumption and ageing, and driven by increasing obesity and inactivity (WHO, 2009a).

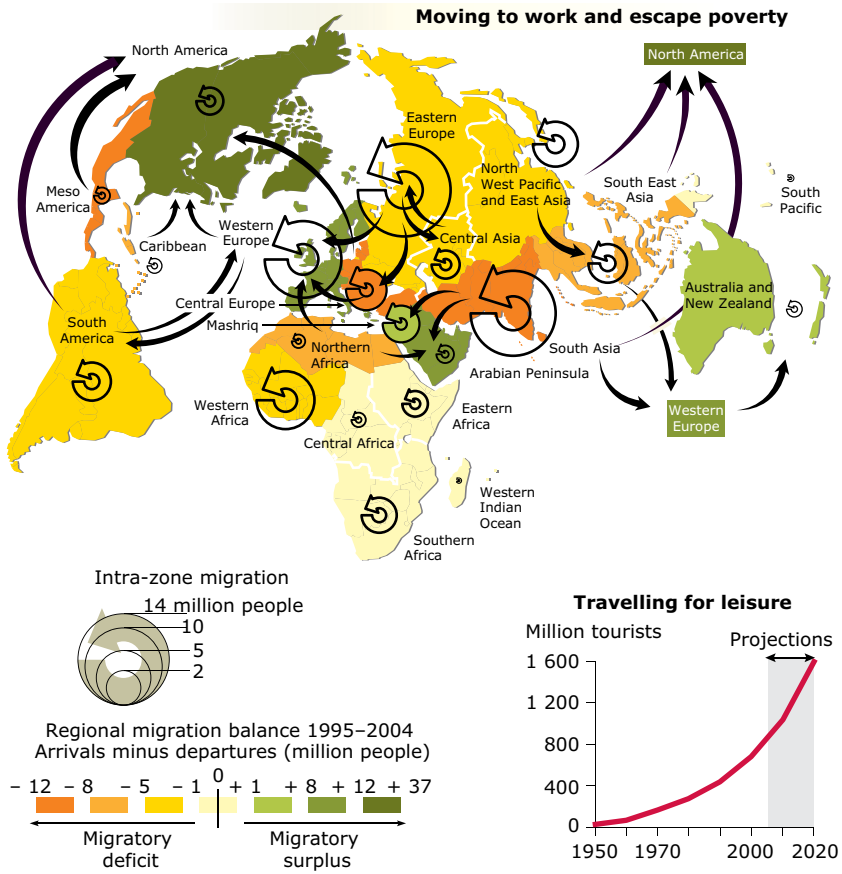
Changes in working, living and travel habits, as well as climate change, alter the disease burden both between and within countries (Arguin et al., 2009). Migration inside and between countries is likewise increasing (Map 3.1). These migrations increase the opportunity for diseases to spread rapidly between populations and may result in the re-introduction of infectious diseases to areas where they had been eradicated (or significantly reduced). They may also hasten the spread of pandemics. For example, tuberculosis has re-emerged and is becoming more common in some developed countries where it had been reduced to extreme lows. This increased incidence has been linked to migrants from areas of high health inequality (WHO, 2009b).

Figure 3.1 Evolution in human health risks as economies develop



Source: WHO, 2004.

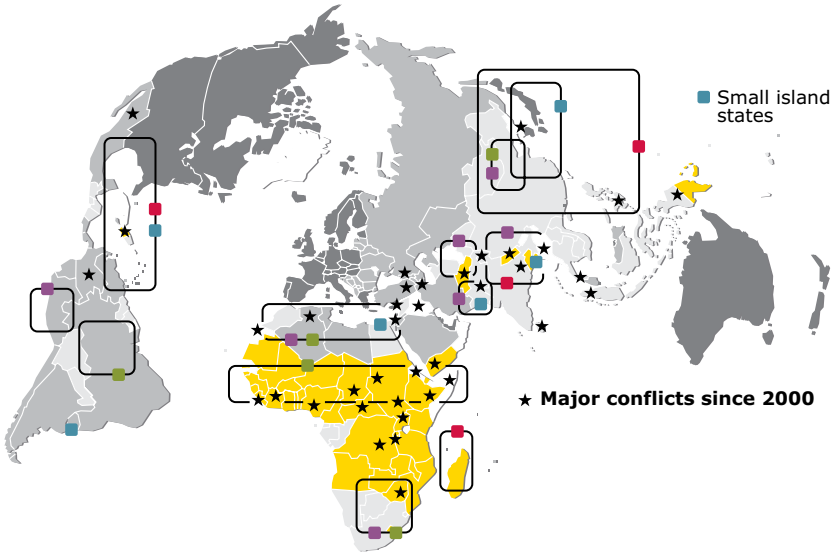
Map 3.1 Movements of people: migration and tourism



Source: DRC, 2007.

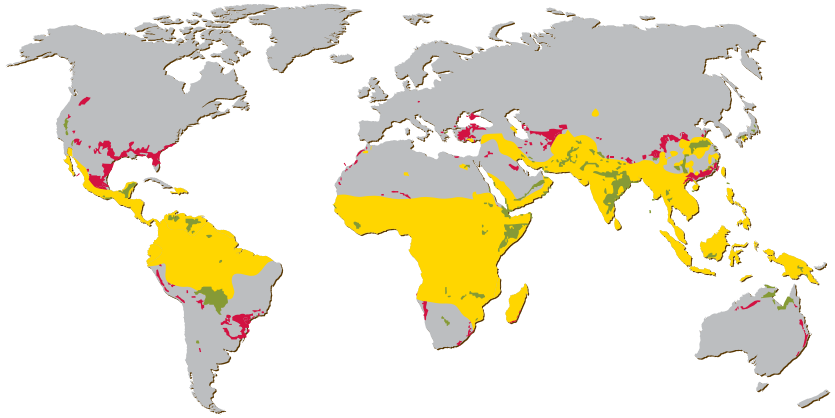
Source: UNWTO, 2008.

Map 3.2 Environmental factors and conflicts that may cause migration



Source: WBGU, 2007; UNDP, 2010; UNEP, 2009; IISS, 2010.

Map 3.3 Malaria by 2050



- Current distribution of *falciparum* malaria [a]
- Unsuitable climate for vector and parasite by 2050 (where malaria could disappear)
- Suitable climate for vector and parasite by 2050 (where malaria could appear)

Notes: The projections are based on the HadCM2 high climate scenario. The areas of appearance and disappearance are about equal in area and number of inhabitants (about 400 million).

[a] *Plasmodium falciparum* is a parasite that causes malaria in humans. It is transmitted by the anopheles mosquito. The current distribution represents the maximum extent of the distribution of the parasite and its vector.

Source: Rogers and Randolph, 2000; Ahlenius, 2005.

Migration inside countries (usually from rural to urban areas) increases the risk of infectious disease, violence and drug dependence, particularly where the migration leads to chaotic slum development, associated with poverty, overcrowding and poor public services. Densely populated urban areas, may pose an even bigger risk of environmental hazards, crime and disease, especially if they are not well managed (WHO, 2008b).

The effectiveness of efforts to manage migration and control disease is hard to predict, partly because of uncertainties in trends and future policies but also because the links between income levels and global pandemics are complex and poorly understood. Significant global disparities will persist in national capacities to manage some transmissible infectious diseases (WHO, 2009b). It is worth investing in prevention globally and at the place of origin of potential migrants to Europe.

Box 3.1 Why are risks of new pandemics important for Europe?

Health is essential for human development. Globally, health standards have improved in recent decades, largely in step with increasing lifespans. The disease burden is unevenly distributed across populations, however, varying with gender and social and economic status (Wilkinson and Pickett, 2006).

Global health megatrends are relevant for European policymaking, particularly by prompting investment in preparedness for increased immigration and the associated risks of emerging diseases and pandemics (Arguin et al., 2009). In addition, environmental changes worldwide are becoming an important a driver of human health (Gilland, 2002).

Global health can have direct impact on Europe, such as the spread of new diseases through immigration or tourism. The risks of exposure to new, emerging and re-emerging diseases or to accidents and new pandemics increase with globalisation (via travel and trade), population dynamics (due to migration and ageing) and poverty. The risk of exposure can be exacerbated trough environmental factors causing migrations, through forced migration, disease and conflicts (see Map 3.1).

The ageing European population is also more vulnerable to both communicable and non-communicable diseases and to health effects related to climate change (for example heat waves and flooding). For Europe, this increased vulnerability may impose significant costs on health systems, which can compete with costs on environmental protection.

Key drivers and uncertainties

Changes in disease burden patterns occur because of global developments such as economic growth, wealth and poverty distribution, increased migration and personal mobility, rapid urbanisation in developing countries and related governmental policies. Other factors include the ability of border security systems to prevent the spread of disease, consumption and dietary habits, access to sanitation and clean water, health care standards, environmental degradation and climate change impacts (WHO, 2008a).

Many of these drivers are affected by uncertainty. For example, how will developed countries invest in health enhancement to prevent the spread of diseases (WHO, 2004)? How will environmental regulation develop? What will be the impacts of climate change? There is also a high risk of unexpected events, for example pandemics and war (NIC, 2008).

The growth of resistance to antibiotics and other drugs, and the failure to address many tropical diseases (Frew et al., 2009), also give rise to concern in both developed and developing countries. However, technology can play an important role in supporting improvements in health status and in spatial monitoring of health patterns, allowing mapping and analyses of geographic patterns of disease trends that were previously overlooked (Bodenhiemer, 2005).

4 Accelerating technological change: racing into the unknown

The breakneck pace of technological change brings risks and opportunities, not least for developed regions like Europe. These include in particular the emerging cluster of nanotechnology, biotechnology, and information and communication technology. Innovations offer immense opportunities for the environment but can also cause enormous problems if risks are not regulated adequately.

Over the last 50 years the pace of innovation and technological change has accelerated consistently. The time needed for basic inventions to enter mass use has steadily decreased. Cycles of technology-induced societal and economic change are becoming faster. And cycles of innovation and technology change are very likely to accelerate further. The history of technological progress provides compelling evidence that change is not linear but exponential (Kurzweil, 2001). The dynamics will increasingly come from the convergence of sciences and technologies: This acceleration technological change will also affect economic sectors that have been slower to change in the past, notably energy and transport.

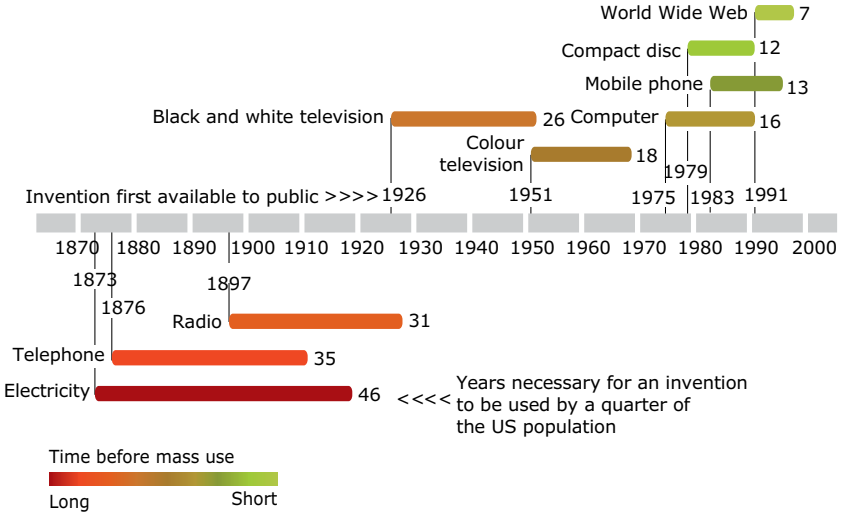
The processes of creating, owning and sharing knowledge are changing in a highly interlinked world; any outlook is fraught with considerable uncertainties. For example, open access to information will continue to empower bottom-up innovation processes, opening new routes for knowledge creation. But private battles may arise, with access to information and user rights becoming more fiercely contested by corporate and private interests.

A digital and technology divide is likely to remain between developed and many currently developing countries. One reason is that many cutting-edge technologies in ICT still depend on infrastructures based on older technologies, for example functioning electricity grids (Kegley and Raymond, 2006). However, more and more often emerging economies are starting to challenge developed economies in

the core areas of their competitive advantage, namely high-technology developments. Competitive pressures will increase as many emerging economies step up their general research and innovation capacities. Increasingly, EU-27 multinationals are competing with technology-based companies from emerging economies in high-end technology markets. Growth rates in patent filings in some Asian economies are beyond the level of several western OECD economies (WIPO, 2009) (Figure 4.2).

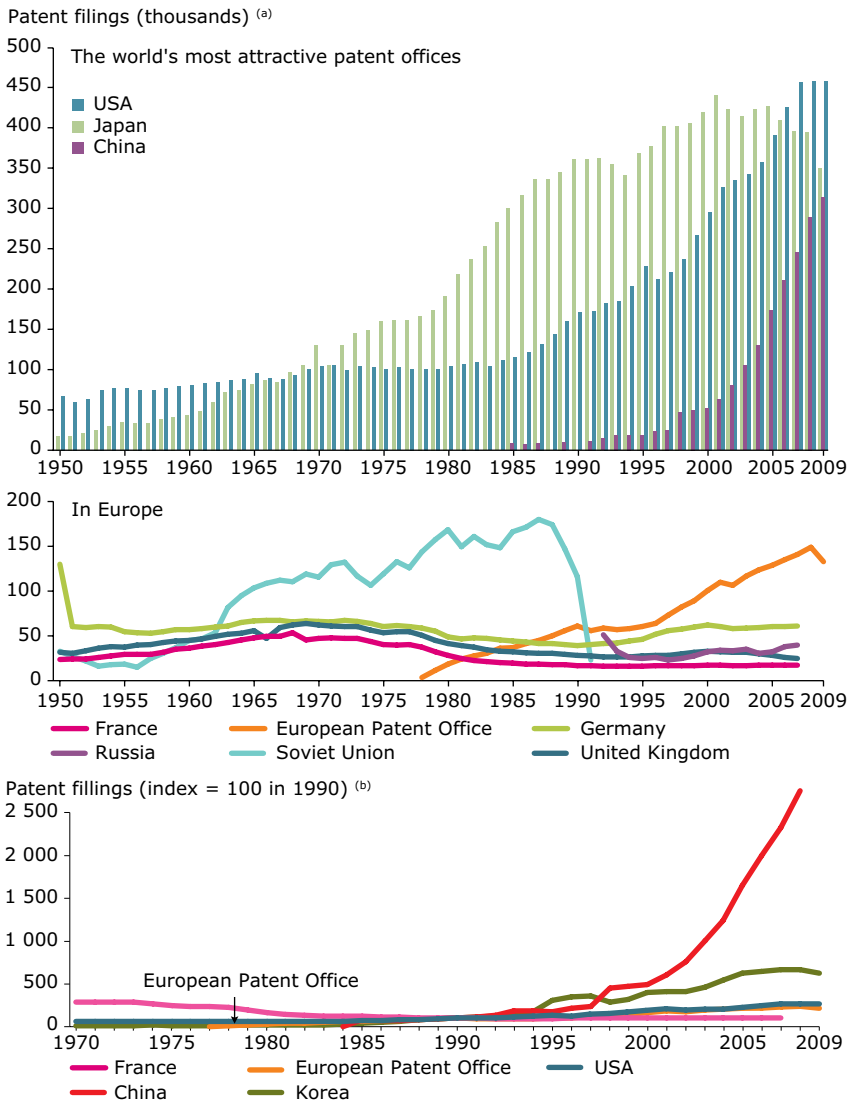
The dynamics of global innovation create an accelerating race into the unknown. This race offers tremendous opportunities for solving pressing environmental problems. But it also increases external dependencies and risks, particularly given the under-investment in water, energy and transport, which underpin most of our economic and technological activities. Risk regulators will increasingly operate under conditions of great, and often irreducible, uncertainty (OECD, 2010).

Figure 4.1 Shortening time lapse before mass adoption of new technologies



Source: Kurzwell, 2005.

Figure 4.2 Patent registration trends



Note: (a) These figures mostly reflect the popularity of patent offices.
(b) Please note that the time scale and the verticale scale are different from the graphics above.

Source: WIPO, 2009.

This balance of opportunities and risks is particularly evident for the cluster of rapidly emerging and converging sciences and technologies in nanosciences and nanotechnologies, biotechnologies and life sciences, information and communication technologies, cognitive sciences and neurotechnologies (the so-called NBIC cluster) (EEA, 2010d; Silberglit et al., 2006). Learning from nature is gaining increasing relevance as a scientific paradigm.

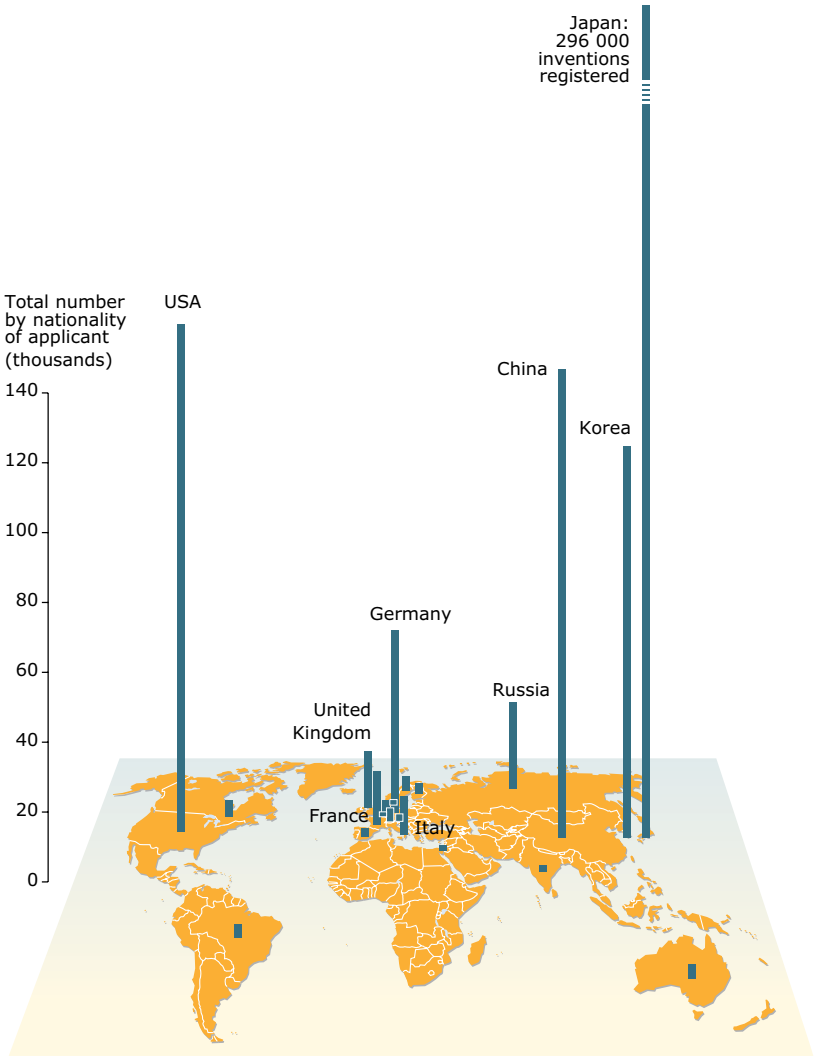
The NBIC cluster is increasingly quickly moving from innovation to application (e.g. nanomaterials) (Nightingale et al., 2008). In spite of all the uncertainties, in 2040–2050 nano- and biotechnologies are likely to be pervasive, diverse and incorporated into all aspects of our daily lives. Expectations range from moderate scepticism to broad enthusiasm, and even include far-reaching assumptions about the control of matter and genes, ubiquitous intelligence and a huge potential to accelerate access to sustainable energy, food supply and universal health-care (Subramanian, 2009).

Many observers agree that the NBIC cluster is likely to form the backbone of the next long-term wave of innovation and growth, changing the ways in which we work, live and communicate. The component elements are very likely to affect many approaches to environmental problem solving.

Nanotechnologies are especially relevant because with decreasing size the properties of materials change. Being able to design and manufacture materials and increasingly complex structures and devices at the scale of atoms and molecules offers many approaches and tools that can vastly enhance our ability to detect and remedy environmental deterioration. Examples include nanotechnologies for energy conversion and storage (for example dye-based solar power cells); replacement of toxic materials; new, lighter materials; and environmental remediation technologies (UBA, 2010).

There is also no end in sight for the increase of computing power: silicon-based chips are likely to be replaced with faster technologies (for example optical or molecular computers), which are capable of much higher speeds. They will greatly improve human abilities to understand and monitor environmental change and develop problem-solving strategies.

Figure 4.3 Patent families [a] registered in 2007



Note: Only countries with more than 1 000 applicants are shown.

(a) A patent family is a set of inter-related patent applications on the same subject. Statistics based on patent families eliminate double counts (i.e. when the same invention is registered in different patent offices).

Source: WIPO, 2010.

Yet scientific committees in Europe and elsewhere, for example the US National Research Council, have expressed major concerns about the environmental and health issues arising from new technologies (SCENIHR, 2009). For instance, the rapid transformation that nanoparticles could undergo when released into the natural environment may render traditional approaches to describing air or water quality inadequate (RCEP, 2008). Currently, there is an increasing gap between the need for and the availability of relevant data and testing methods to understand, for example, the toxicology and exposure paths of novel materials in the environment (McGarvin, 2010).

Box 4.1 Why is the accelerating pace of technological change important for Europe?

The 2010 *State of the Future Report* from the Millennium Project (Glenn et al., 2010) observes that while humankind is devising ever more sophisticated ways to improve the human condition, global problems seem to be increasing in complexity and scale. Innovation is a key driver of economic growth and increasing welfare, and can contribute directly and indirectly to damaging or improving the environment. Many promising technological solutions are already available or could be available in a short time but are being poorly implemented. In general, R&D efforts have increased globally but environmental R&D retains a low share of the total. Similarly, environmental patenting is not keeping pace with the growth in overall patenting (Johnstone et al., 2010).

Approving new technologies in regions with weaker risk assessment and governance structures can create risks that could easily spread across our highly interlinked world. Unclear delineation of public and private responsibilities is likely to magnify controversies about risk control and associated costs. This challenge particularly concerns the NBIC cluster.

While new technologies are an indispensable part of any strategy to address problems of global environmental change, previous experiences with technological fixes show the possibility of simply shifting the source of the problem and creating new problems along the way. However, the legal requirement to apply the precautionary principle in the EU helps manage potentially harmful technologies and stimulate smarter, less threatening innovations.

Key drivers and uncertainties

Efforts to accelerate basic technological development cycles are driven by better access to information and increasing scientific cooperation, building upon continued economic growth and trade. The value creation and competitiveness of many companies in the OECD world is determined not just by the price of their products but also their ability to innovate and remain at the forefront of technological progress. Rising levels of education together with increased per capita incomes in many parts of the world mean that demand for new products is growing, leading to shorter product innovation cycles.

The general acceleration of innovation and technological change is a stable trend. But the concrete direction and speed of innovation and diffusion is very uncertain. Technological constraints are key uncertainties — many of the NBIC technologies are still in the laboratory. But there are also important uncertainties regarding the availability of R&D funding because of public and corporate budget constraints, public policy development and the availability of a sufficiently skilled labour force, which could be affected by barriers to international migration. Many applications of NBIC technologies might also trigger ethical concerns.

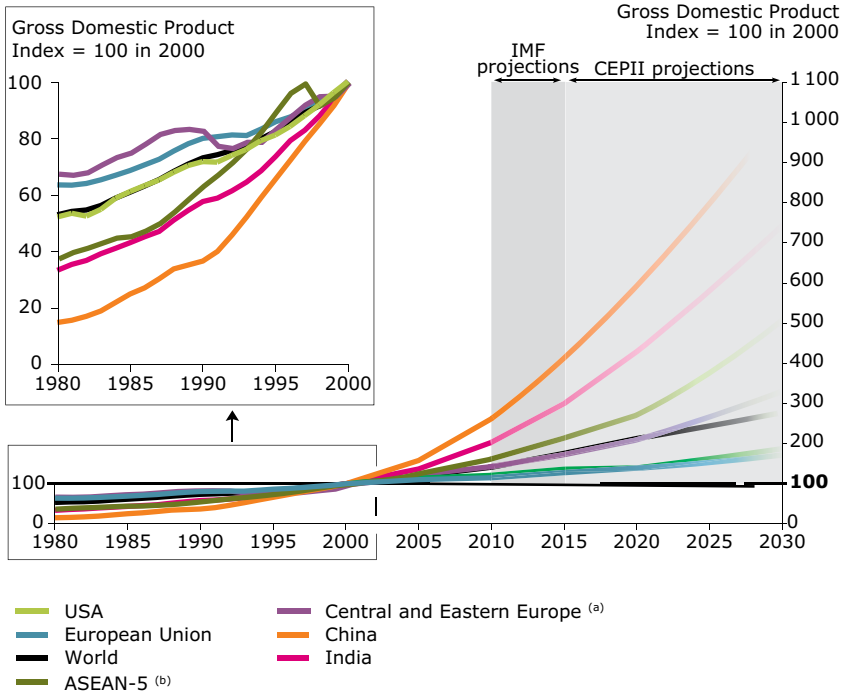
5 Continued economic growth?

Rapid growth accelerates consumption and resource use. But it also creates economic dynamism that fuels technological innovation, potentially offering new approaches to addressing environmental problems and increasing resource efficiency.

Virtually all mainstream outlook studies assume that economic growth will be positive on average across the globe in the coming decades. The rate of growth seems more uncertainty than previously, however, given the depth of the 2008–2009 economic crisis, which was unprecedented since 1945. Due to developments such as ageing and the need for more controls on financial markets, growth may be less than usually assumed in the past, in particular in the developed world. For example the European Commission's 2009 report on the implications of ageing in the EU revises the EU's average Gross Domestic Product (GDP growth expectations in the period to 2060 downward — from 2.4 % to about 1.8 %) (DG ECFIN, 2009).

IMF data show that the world economy grew by 3.2 % annually on average in the period 1980–2010. Developed economies grew 2.6 % annually on average, while China and India grew by 10.0 % and 6.2 % respectively in the same period. Although the gap in terms of GDP per capita (in purchasing power parity terms) between the USA and China has decreased considerably, it still is wide, standing at USD 45 000 in the USA and USD 5 400 in China. Poverty in China has been reduced considerably but in 2005 10 % of Chinese people still lived on less than USD 1 a day, against 35 % in 1990 (IMF, 2010). Although developing economies now account for a larger share of the world's GDP, some regions, in particular Africa, have lagged behind due to trade barriers in agricultural markets.

Figure 5.1 Economic growth continues — faster in emerging economies

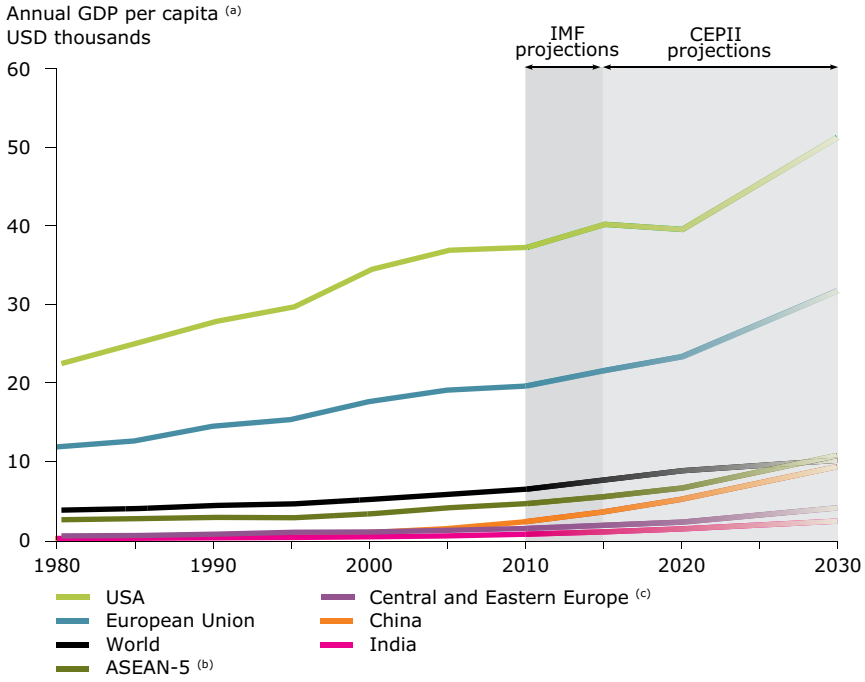


Note: (a) Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, the former Yugoslav Republic of Macedonia, Montenegro, Poland, Romania, Serbia, Turkey.
(b) Indonesia, Malaysia, Philippines, Thailand and Vietnam.

Source: IMF, 2010; Poncet, 2006.

GDP projections up to 2050 assume somewhat reduced growth in the developed and developing economies (2.3 % against 2.6 % in the period 1980–2010) but still a relatively high growth in the emerging economies (e.g. China with 5.3 % and India with 5.2 %) (Poncet, 2006). According to these forecasts, by 2050 more than half of the world's GDP could be earned in the regions now labelled as emerging and developing, against a third in 2010. However, the USA is still projected

Figure 5.2 A large gap persists between advanced and emerging economies



Note: (a) Calculations of GDP per capita are based on UN 2008 median variant population projections and at constant 2000 prices.
(b) Indonesia, Malaysia, Philippines, Thailand and Vietnam.
(c) Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, the former Yugoslav Republic of Macedonia, Montenegro, Poland, Romania, Serbia, Turkey.

Source: IMF, 2010; Poncet, 2006; UN Population Division, 2008.

to be the biggest economy with the EU ranking second and China third (in constant prices, and exchange rates). China could however surpass the world's average GDP per head by 2050 (GDP exchange rates).

Box 5.1 Why is continued economic growth important for Europe?

Significant economic changes have important impacts across almost all areas of society. Economic growth is a central driver of environmental impacts, with slower growth generally implying a reduced environmental impact, although not necessarily securing a healthy environment in the long term. Slow or negative growth characterises economies with reduced efficiency and little innovation, which can increase environmental impacts, as well as reducing the funding available to maintain the environment.

Positive economic growth changes consumption patterns, in particular in emerging countries with a rapidly growing middle class. Mobility increases, durable consumption goods are replaced rather than repaired, and high-calorie food squeezes out low-calorie alternatives. It all leads to increased pressure on the environment and natural resources through increased demand for resources and growing emissions of pollutants. Although in many areas resource efficiency is increasing and the relative pollution content of our lifestyles is tending to fall, the sheer volume of economic activities is pushing resource use and pollution volumes to higher absolute levels.

This megatrend will have both a direct and an indirect effect on Europe's environment. Directly, economic growth increases the burden on the natural systems that sustain us. Indirectly, global economic development affects Europe's position and competitiveness, with economic, social and environmental consequences. Emerging economies have competitive advantages in low-skilled, labour-intensive production and gain further when they build up their capital stock and increase the quality of their products. Europe needs to maintain its high labour productivity and further increase it through technological innovation, but will nevertheless lose its share in some basic markets such as agricultural products and basic manufacturing.

The European population is demanding an ever higher quality living environment. Achieving this will depend on the success of coordinated environmental (climate, biodiversity, pollution) policy measures creating a level playing field for European economic sectors.

Key drivers and uncertainties

Continuing global economic growth is mainly driven by population growth, further market globalisation and technological innovation. Other major factors are supportive economic policies at national, regional and global levels. The world has always seen longer or shorter cycles of economic upswing and recession. Periods of depression have always been followed by a return to a positive growth path, with several growth engines through time (the USA and Japan in the past, the BRIC countries at present). This pattern can be disrupted severely as for instance in the 1930s (the Great Depression), the 1970s (the energy crisis) and 2008/2009 (the financial crisis). There is no certainty that such disruptions will not become more frequent and deeper, keeping the world economy from a positive growth path for a longer period of time.

Key uncertainties include the effects of intensifying resource scarcity, such as short-term scarcity of essential resources (for example food and energy in 2007–2008) and, even more so, long-term scarcity, such as the expected and feared 'peak oil'. The emergence of national policies and bilateral agreements aiming to monopolise natural resources are important in this context. The pace of technological innovation needed to sustain economic growth under higher resource prices and possible larger disruptions is uncertain, as is the stability of financial markets. For emerging economies in particular, socio-political developments (e.g. democratisation) are an uncertainty, as is their ability to adapt to reduced skilled labour due to ageing in the long term. The last and perhaps most important uncertainty concerns geopolitical stability and the absence of military conflicts.

6 From a unipolar to a multipolar world

Global power is shifting. One superpower no longer holds sway and regional power blocs are increasingly important, economically and diplomatically. As global interdependence and trade expands, Europe may benefit from improving its resource efficiency and knowledge-based economy.

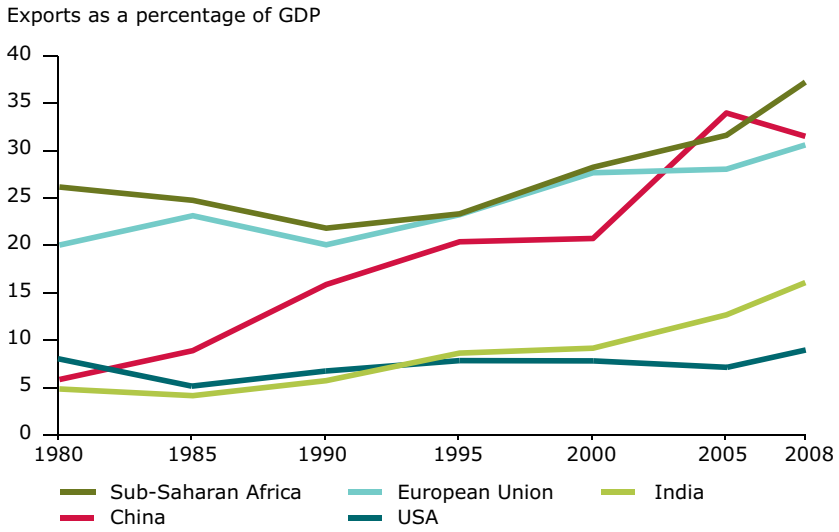
The data and projections on global and regional economic growth show that an increasing share of the world's GDP will be created in emerging and developing regions. The USA's share of global GDP is projected to decrease from 26 % in 2010 to 23 % by 2050. For the EU these figures are 22 % in 2010 and 17 % by 2050. China's share is expected to grow from 7 % to 18 % in the same period in this outlook. For India and the ASEAN-5 countries, projections are equally impressive, from 2.1 % to 5.1 % for India and from 1.7 % to 4.8 % for ASEAN-5 (IMF, 2010).

Another indication of continuing globalisation and the growing role of emerging countries in the world economy is the increase in their exports as a proportion of national GDP. For the world as a whole this figure grew from 20.5 % in 1980 to 27.1 % in 2009. A similar pattern is apparent in the EU: 20.1 % in 1980 and 26.3 % in 2009. In India it grew from 4.8 % to 13.0 %. The USA has had a fairly constant export to GDP ratio through time, at about 7–9 % (Figures 6.1 and 6.2).

Fast-growing countries may even gain more in economic influence than their growth rates suggest when their middle class consumers grow in numbers and start to spend discretionary income on modern, short-cycle consumer goods, becoming attractive export markets for advanced economies (Accenture, 2008). Foreign firms locate in these countries to profit from growing demand, and to use cheap and skilled labour when available. The Fortune Global 500 list included 46 companies located in China in 2010, against just 16 in 2005.

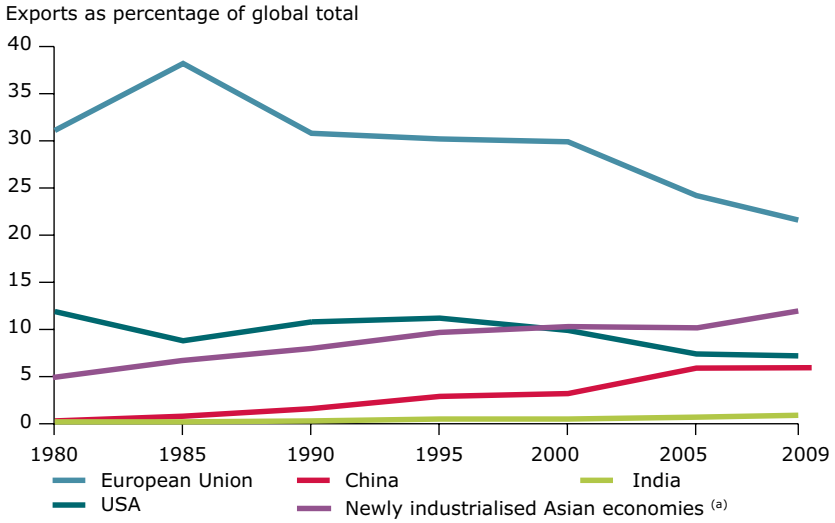
The ratio of foreign direct investment (FDI) to GDP grew for the world as a whole from 0.43 % in 1980 to 5.4 % in 2007 (although 2008 and 2009 show drastic reductions due to the economic crisis: 63 % lower in 2009 compared with 2007 at world level). FDI into China rose from 0.5 % of national GDP in 1985 to 5.8 % in 2007. In India it grew from zero to 3.3 % in the same period. The figure for central and eastern Europe clearly shows the impact of economic integration resulting from EU accession in 2004 and 2007, rising from 3.0 % of aggregate GDP in 2000 to 19.0 % in 2007. The increased ratio of FDI to GDP indicates increasing global interdependency, which is driving increased efforts to bring down trade barriers through international agreements.

Figure 6.1 The weight of trade



Source: IMF, 2010.

Figure 6.2 Share of global exports



Note: (a) Hong Kong, Korea, Singapore and Taiwan.

Source: IMF, 2010.

Economic power concentration will tend to diversify — from a unipolar (USA) to a multipolar global economic map — when BRIC countries and subsequent emerging economies (Indonesia, South Africa, Vietnam and others) grow in economic significance (NIC, 2008; Poncet, 2006). For example, by 2050 the Asia-Pacific block is expected to be China's second biggest trade partner, whereas it ranked fifth in 2006. Latin America is expected to be the USA's biggest trade partner, moving from third in 2006 (Figure 6.3).

This power shift may be reinforced when countries form blocs and act in concert, as the EU has pioneered. The euro is now a leading currency, alongside the yen, the renminbi and, most importantly, the US dollar. Several forms of cooperation exist, including free trade agreements such as NAFTA in North America and SAFTA in south Asia, which can provide a step towards closer economic and political integration.

Figure 6.3 Shifting trade flows

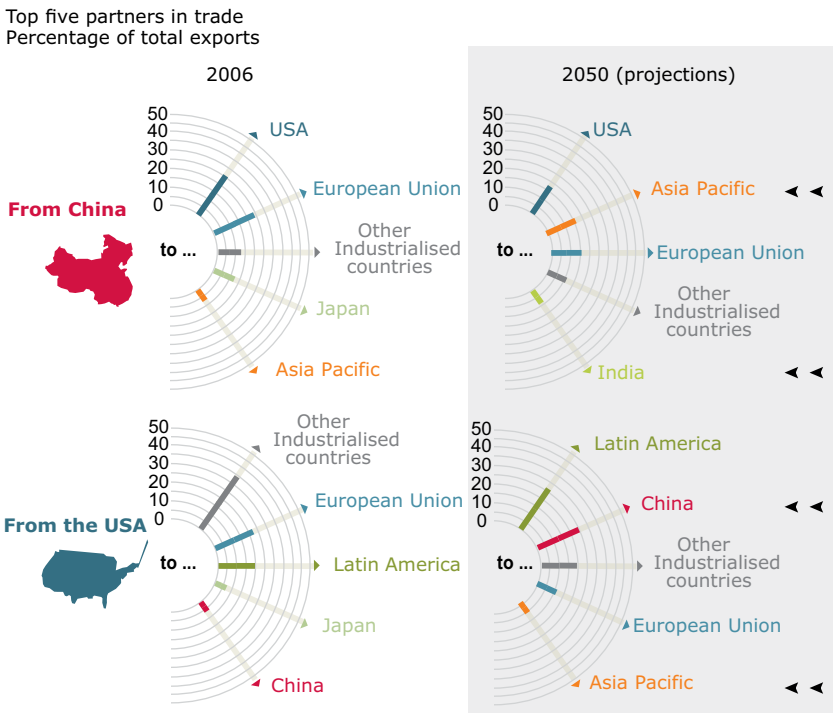
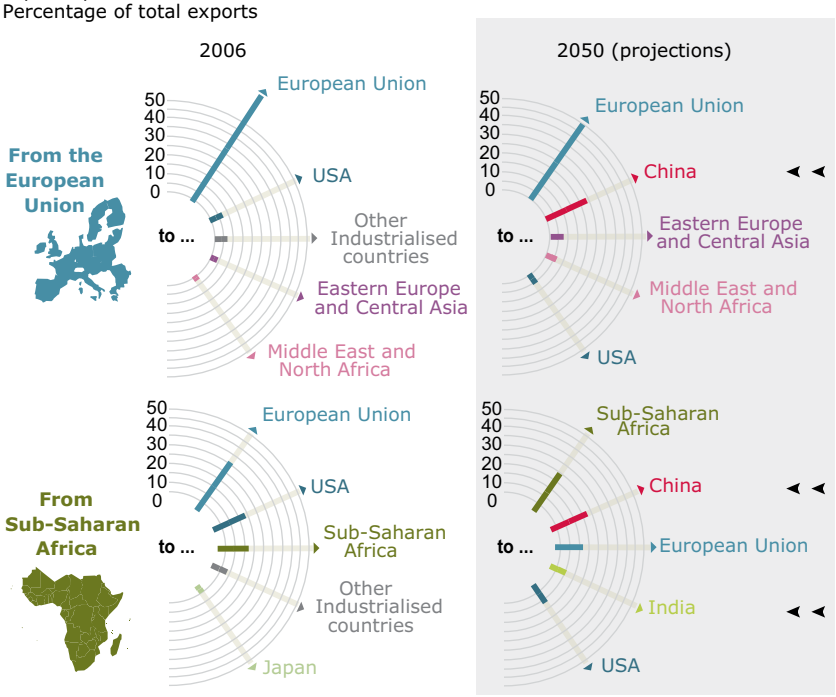


Figure 6.3 Shifting trade flows (cont.)

Top five partners in trade
Percentage of total exports



Source: Dadush and Shimelse, 2010.

ASEAN is a geopolitical and economic organisation in South East Asia comprising 10 countries, economically dominated by Indonesia, which accounts for about a third of its combined GDP. ASEAN has established free trade agreements with China, South Korea, and Japan (ASEAN plus three) and in 2003 the goal was set to create an ASEAN Economic Community by 2020. Parallel to this, regional cooperation has progressed in south Asia and the Gulf region and in 2002 the Asia Cooperation Dialogue (ACD) was created to promote Asian cooperation at a continental level with the ultimate goal of transforming the continent into an Asian economic community (ADB, 2007).

Box 6.1 Why is this global power shift important for Europe?

When countries grow relatively fast they gain in economic power through their enlarging production and consumption markets. They are able to exercise that power at international negotiations on economic matters (such as trade barriers and product standards) but also in a wider sense, including participation in climate change and other environmental negotiations.

Countries not only gain power through sheer size and prosperity but also through their level of technological development and ownership of important resources. In the early stages of development economic growth may be driven by increased labour productivity supported by capital accumulation. When developed countries gain access to local markets in developing countries, for example for outsourcing certain economic activities, technological diffusion is likely to speed up and fertilise innovation in the host countries. That gives a boost for further productivity growth and increased prosperity and economic power.

Owning essential natural resources may further improve emerging economies' competitiveness. Their growing demand for resources stimulates domestic exploration and exploitation, possibly increasing the countries' share in the total global stock. Resolution of open ownership claims with regards to continental shelf rights, such as in the Arctic Ocean, also stands to shift the relative distribution of natural resources. Perhaps more important, crucial mineral sources for new technologies tend to be very unevenly distributed over the globe. For example, more than half of the world's stock of lithium, a metal at present essential for hybrid and full-electrical cars, is believed to be located in Bolivia, with huge economic potential.

Economic growth rates vary globally as countries and blocs gain and lose competitiveness, with trade flows shifting accordingly. These changes can fundamental influence the Europe's economic activities, including where and how it earns income. Emerging economies traditionally earn the largest part of their income from agriculture and industry. In China, for example, these two sectors accounted for 60 % of GDP in 2008. In advanced economies these sectors tend to diminish as a proportion of the economy overtime, with the services sector becoming dominant. The share of the services sector in China is 40 % against 77 % in the USA and 74 % in the EU.

Europe currently faces competition from emerging economies primarily in industrial and agricultural markets. In the future, however, it will increasingly be felt in the services sector as well. Europe will need to find its own niche to maintain its income levels. Its relative resource poverty may lead to a more resource-efficient economic structure, leaning further towards being a service economy. For example, with increasing purchasing power in emerging economies, Europe may become more and more attractive as a tourist destination.

Its economic profile will determine where and how Europe will use natural resources and affect the environment, both domestically and abroad. This megatrend will therefore have a direct and indirect effect on Europe's environment.

Key drivers and uncertainties

Key factors influencing a global shift of economic power from the advanced economies to the emerging economies are, first of all, the rates of productivity and income growth in emerging economies, which are outpacing those in advanced economies. Other important drivers are similar to those underlying continued economic growth: population growth, continuing technological innovation and diffusion of technologies, favourable economic policies and integration at regional and global level (Maddison, 2001).

Major uncertainties include the ability of emerging economies to secure access to key resources under changing scarcity patterns and to maintain or gain an additional competitive edge vis-à-vis the advanced economies. As with the issue of economic growth more broadly, there are also uncertainties over whether technological innovation will proceed fast enough to sustain economic growth despite increasing resource prices.

Socio-political developments (for example democratic processes, growing income disparities, and potential ethnic conflicts) are a particular uncertainty, as is the effect of adapting to reduced availability of skilled labour due to possible mass migration in the short term and ageing in the longer-term future. A specific uncertainty is the ability of emerging countries to develop economic cooperation mechanisms and further economic integration, which will reinforce their position on the global stage. The last and perhaps most important uncertainty concerns geopolitical stability and the absence of military conflicts.

7 Intensified global competition for resources

How will Europe survive in the intensifying scramble for scarce resources? The answer may lie in more efficient production and resource use, new technologies, innovation and increasing cooperation with foreign partners.

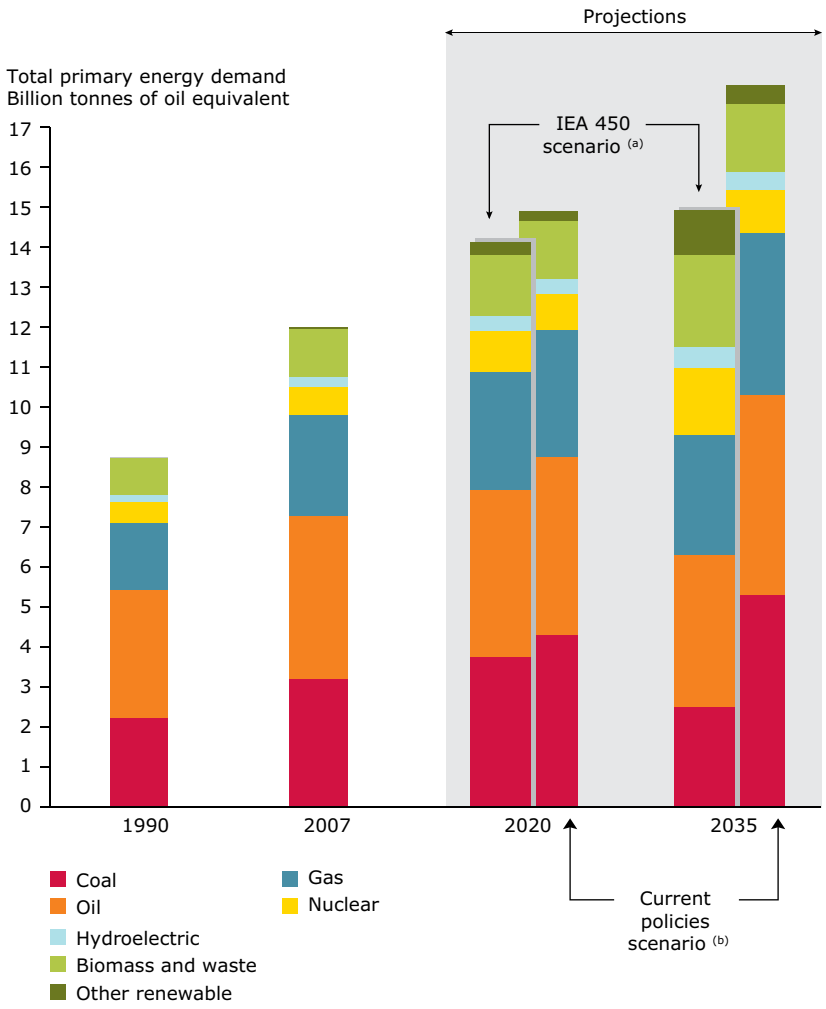
Economic growth is continuing globally and is accelerating in BRIC countries and other newly emerging economies. Demand for fossil fuels and other subsoil and natural resources is likely to grow in absolute terms despite continuing and partly successful efforts to increase the resource- and energy-efficiency of economic activities.

Fossil fuels will remain the most important energy source, at least until 2030, and the use of oil, gas and coal is expected to grow in volume (IEA, 2009) over this period. Coal is not scarce but is problematic for pollution and climate change reasons. The production costs of oil continue to rise with the expanding share of deepwater exploitation in total supply (IEA, 2008) (see Figure 7.2). Although coal and gas are abundantly available, environmental and logistical reasons prevent a substantial shift away from oil to these energy sources.

Fossil fuel reserves are concentrated in a small number of countries. Some 80 % of the coal reserves are located in just six countries and the EU has just 4 % of the global total. The EU share of the world's gas reserves decreased from 4.6 % in 1980 to 1.3 % in 2009 and these reserves are expected to be exhausted before 2030. More than half of the global stock is found in only three countries: Iran, Qatar and Russia, which accounted for (24 % of the total in 2009 and is a major gas supplier for the EU.

Ten countries (of which eight are OPEC members) have 80 % of the world's oil reserves. Some of these countries may exercise their power to restrict supply or influence the price (NIC, 2008). EU dependence on imported fossil fuels — currently accounting for over 50 % of fuels consumed — is slowly rising. Some EU Member States (for instance

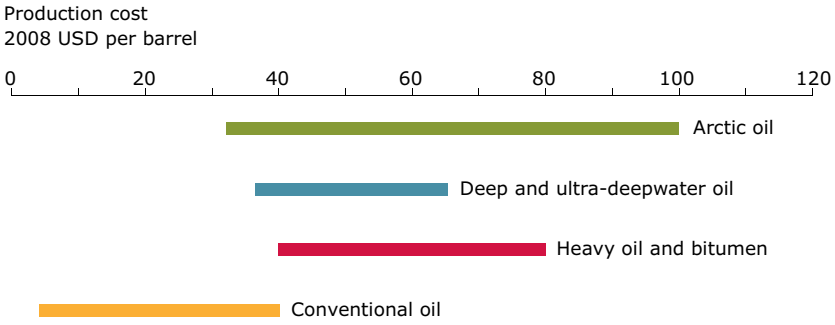
Figure 7.1 World energy demand



Note: (a) The 450 scenario is based on greenhouse-gas emission-reductions and other commitments associated with the Copenhagen Accord; on other policies currently under discussion or announced but not yet implemented; and on the extension or strengthening of some policies already in force and included under current policies scenario.
(b) The current policies scenario includes all policies in place and supported through enhanced measures as mid-2010.

Source: IEA, 2008.

Figure 7.2 Cost of oil production



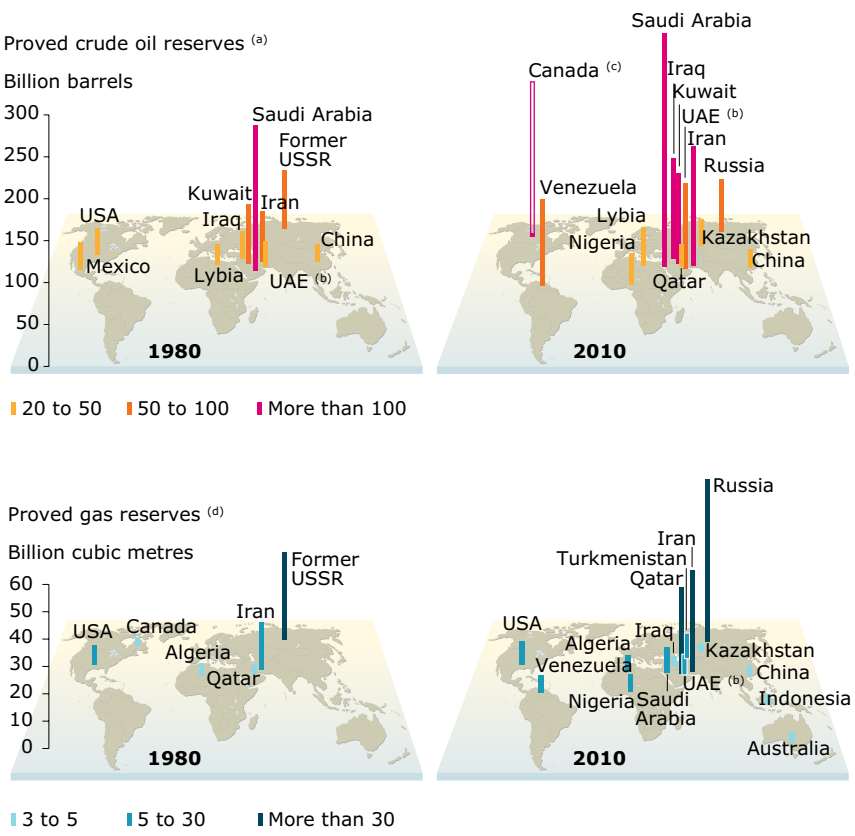
Source: IEA, 2008.

Estonia, France, Italy and Sweden) have sizeable oil shale stocks and reduced foreign supply may encourage them to exploit these sources. The Arctic region is expected to contain a substantial amount of oil, probably up to 90 billion barrels, which is 7.5 times the estimated EU reserves of about 12 billion barrels.

Stocks of 14 groups of raw materials are considered 'critical' due to their high economic importance and high supply risk within the next 10 years. The EU has very few reserves of some, such as gallium (used in photovoltaics and microchips), tantalum (used in microelectronic capacitors), germanium (used in fibreglass cables) and neodymium (used in high performance magnets), which are essential for high-tech applications (Fraunhofer and IZT, 2009; EC, 2010).

The demand for phosphorus, most of which is used as agricultural fertiliser, is predicted to increase by 50–100 % by 2050 with increased global demand for food and changing diets. The remaining potential reserves are of lower quality or more costly to extract. Phosphate rock reserves are in the control of only a few countries, mainly Morocco (with nearly 40 % of global reserves), China and the USA, and are thus subject to international political influence. There is no substitute for phosphorus and, with very small EU stocks, imports will be essential for Europe's development.

Figure 7.3 Selected oil and gas reserves



Note: The countries represented here hold stocks of 80 % of global proved reserves in oil and gas
(a) Only countries with more than 20 billion barrels are shown.
(b) United Arab Emirates.
(c) Including 172.3 billion barrels of oil sands and 5.2 billion barrels of conventional oil and condensate.
(d) Only countries with more than 3 billion cubic metres are shown.

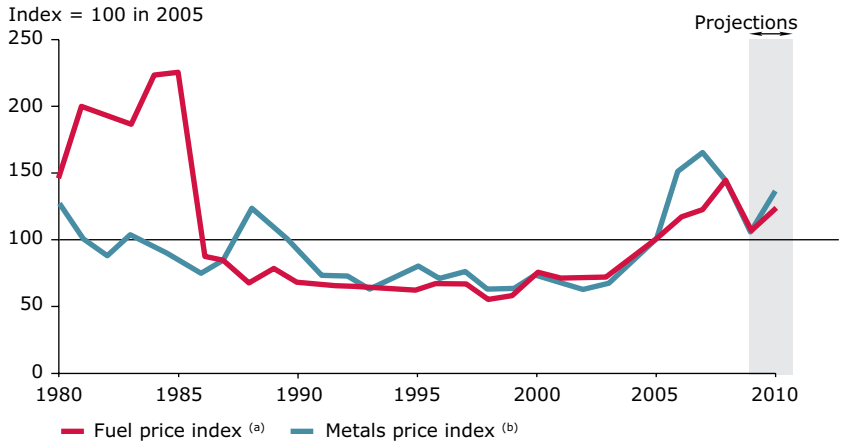
Source: EIA, 2010.

Increased demand for subsoil resources will stimulate exploration and exploitation of new sources (Maddison, 2001). Supply is expected to meet rising demand, both for 'bulk' resources like fossil fuels and minerals, and for metals that are essential for environmental technologies.

Prices of bulk resources (fossil fuels and a selection of metals such as copper, aluminium, iron, tin, nickel, zinc, lead and uranium) may be seen as reflecting their scarcity. Data show a fairly constant price level throughout the 1990s and an increase in the 2000s disturbed by the 2008–2009 economic crisis (Figure 7.4). This may indicate a continuing availability of these resources at the global level with shocks inducing short-term price increases (IMF, 2010; World Bank, 2009).

The increased need for strategic resources may stimulate political monopolisation of access (for example China's moves to secure resources in parts of Africa in recent years), which may complicate access for other purchasers, including the EU.

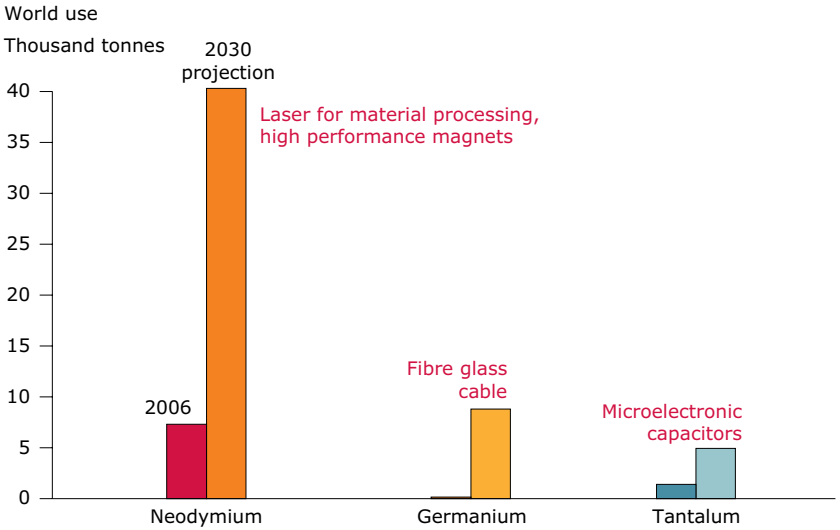
Figure 7.4 Price of fossil fuels and metals



Note: (a) Including crude oil (petroleum), natural gas and coal.
(b) Including copper, aluminum, iron ore, tin, nickel, zinc, lead and uranium.

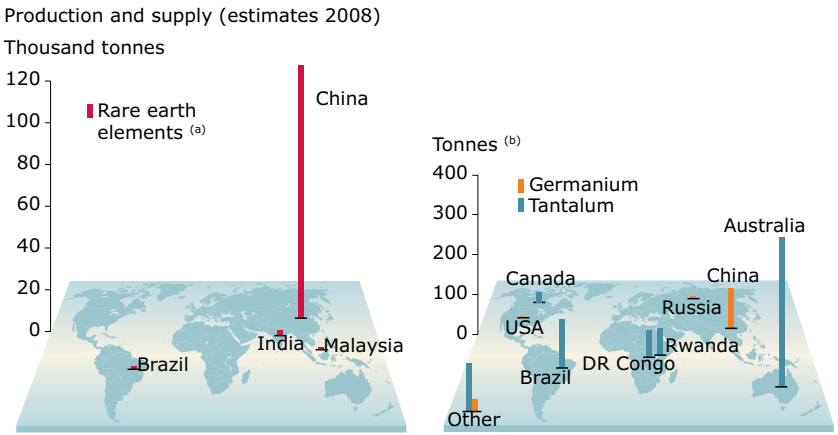
Source: IMF, 2010.

Figure 7.5 Use and supply of selected raw materials



Note: In red: selected technologies responsible for the growth in use of these minerals by 2030.

Sources: Fraunhofer, 2009; USGS, 2004.



Note: (a) Rare earth elements are a collection of 17 chemical elements, including Neodymium.
(b) Please note variations in the vertical scale.

Source: Angerer et al., 2009; USGS, 2010b.

Box 7.1 Why is intensified global resource competition important for Europe?

Secure access to resources is crucial for European production. Europe is relatively resource poor and needs to import much of the resources it requires. This is especially true assuming continuing growth in demand for energy and the resources needed for advanced environmental technology solutions. Europe may, under the pressure of increased competition from the emerging economies, find market niches that would reduce its overall need for minerals and metals.

To meet its growing energy needs Europe relies on foreign resources. The environmental effects of expanding exploitation fall largely outside Europe, implying a growing global footprint. Increasing scarcity of fossil fuels may stimulate greater efforts to shift to other energy sources that can be found domestically. This may have various effects on Europe's environment, including increased land use for biofuels, disruption of ecosystems from developing hydropower capacity, noise and visual pollution from wind turbines, and the impacts of expanding oil shale exploitation. Expanding nuclear energy capacity will trigger public debate about waste storage and safety risks.

Similarly, growing long-term scarcity of minerals and metals may induce Europe to turn to sources previously deemed uneconomic. Expanding mining has environmental effects, including altering landscapes, polluting water and generating waste. Exploiting poorer reserves, with lower extraction rates, may lead to reduced energy efficiency.

Key drivers and uncertainties

The key drivers of intensifying competition for resources are continuing economic growth and related growth in numbers of middle-income consumers. Depleting resources and changing geographical patterns of demand and supply influence access to key resources. Technological innovation will boost demand for certain minerals and metals not widely used before (such as lithium and rare earths metals). Efforts to expand the membership of trade agreements and other forms of economic integration may be important to alleviate competition over resources.

Major uncertainties include the continuation and global pattern of economic growth, the future direction and application of technological innovations such as the NBIC technology cluster and changing demand for certain resources. On the supply side, new reserves may be found. Some reserves may be too costly to exploit, however, because of environmental considerations (e.g. in the Arctic). Global progress in environmental agreements (e.g. on strict preservation of the Arctic environment) could exclude or reduce the availability of such resources. Geopolitical instability may hamper new trade agreements and other pacts that smooth international trade and reduce resource competition.

8 Decreasing stocks of natural resources

A larger and richer global population with expanding consumption needs will place growing demands on natural systems for food, water and energy. European resource stocks may likewise face increasing pressures.

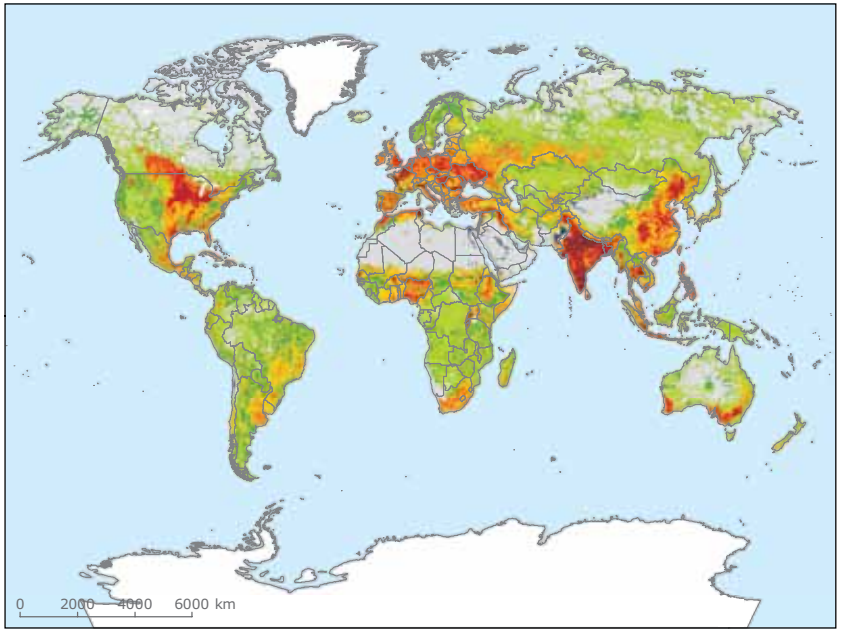
Growing human demand for natural resources, driven by continuous population growth and increasing individual consumption, has resulted in large-scale land conversion (deforestation, cultivation and urbanisation) and loss of biodiversity (MA, 2005). While biodiversity loss could be regarded as a megatrend in its own right, it is included here because land conversion and loss of natural ecosystems are central to changes in biodiversity. Humans have converted about a quarter of the Earth's potential net primary production ([5]), either through direct cropping (53 %), land-use-induced productivity changes (40 %) or human-induced fires (7 %). As shown in Map 8.l, the combined impact on natural ecosystems is biggest in North America, Europe and south-east Asia (Haberl et al., 2007).

Deforestation is occurring on an alarming scale, particularly in the tropics. The net area lost annually has decreased substantially, however, from approximately 83 000 km^2 per year in the 1990s to just over 50 000 km^2 per year from 2000–2010. The historical large-scale forest loss in temperate regions has come halted and forest cover there is slowly increasing again with a net gain of 30 000 km^2 in the period 1990–2005. Projections of forest cover by 2050 vary considerably depending on the underlying assumptions, but most studies indicate further overall decline (FAO, 2010; Leadley et al., 2010).

The significant growth of the world's population in coming decades and the shift in diets from cereals to meat as wealth increases may cause demand for agricultural production to rise steeply. According

([5]) Primary production is the production of organic compounds from atmospheric or aquatic carbon dioxide, mainly through photosynthesis.

Map 8.1 Human use of terrestrial ecosystems



Note: (a) Primary production is the production of organic compounds from atmospheric or aquatic carbon dioxide, mainly through photosynthesis. This maps shows human appropriation of net primary production (HANPP) as a percentage of potential net primary production (NPP). HANNP can be calculated in different ways, depending on the reference value for primary production. For estimating the impact on natural ecosystems, this can be related to an estimated primary production of the potential natural vegetation. In this definition, HANPP also takes changes in primary production resulting from land conversion into account.

Source: Haberl et al., 2007.

to the United Nations Food and Agriculture Organization (FAO), demand for food, feed and fibres could grow by 70 % by 2050 (FAO, 2009).

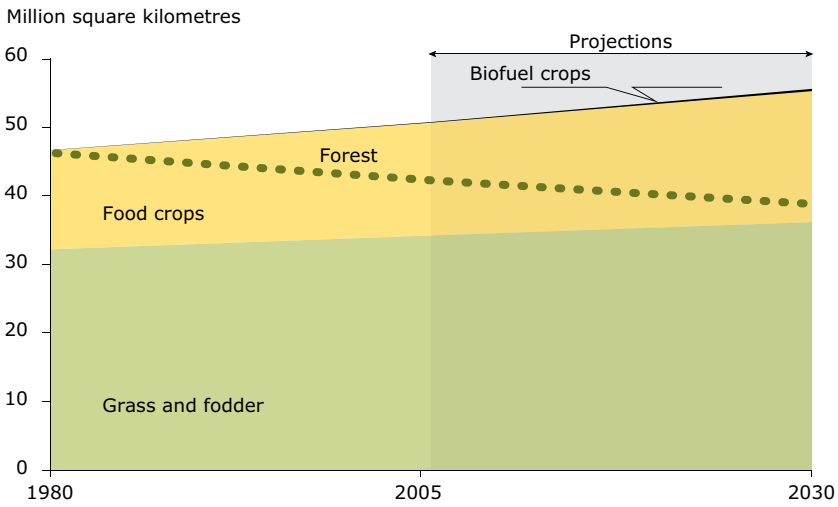
This growth in demand for agricultural output would have considerable implications for land use and natural ecosystems. A projected population increase of 27 % and a wealth increase of 83 % by 2030 would imply a demand for agricultural production that is 50 % higher than today's. Even if agricultural productivity increases at current rates, it would be necessary to expand the global agricultural area by roughly 10 % to meet demand (PBL, 2008; OECD, 2008, see also Figure 8.1).

Unsustainable management practices, however, may in the long run jeopardise productivity. Deforestation and improper agricultural management have already led to large-scale soil degradation. A common problem is soil erosion by surface water runoff, which ultimately reduces food production capacity (Map 8.2). Areas with high water erosion sensitivity are projected to increase by more than one third to some 27 million km^2 in 2030, nearly one fifth of the world's land area. The most impacted regions are in China, India, Africa, the USA and South America (OECD, 2008; PBL, 2008).

Overexploitation of natural resources and associated land use change ultimately leads to ecosystem degradation and loss of biodiversity. Habitat loss and species declines are projected to occur in most regions, most notably in the tropics (Figures 8.2 and 8.3).

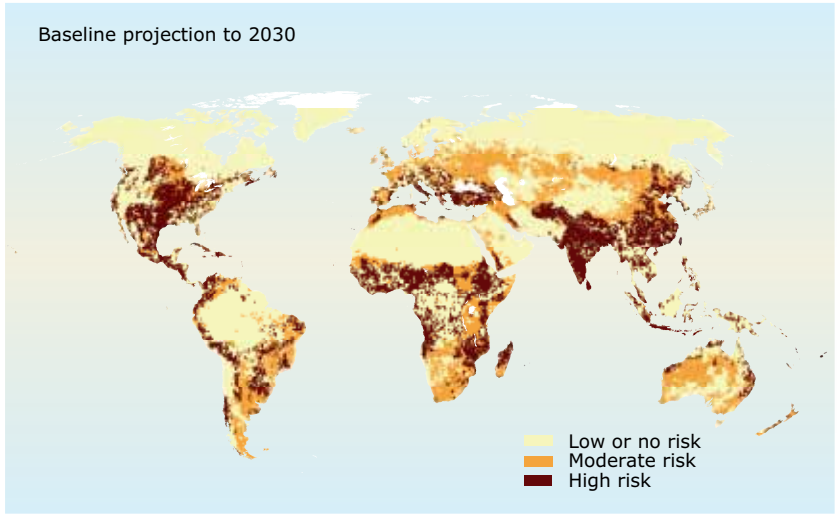
As for the marine environment, a recent study shows that 40 % of the world's oceans are severely affected by human activities (WWF, 2008). About 80 % of the world's marine fish stocks for which information is available are fully exploited or overexploited (CBD, 2010).

Figure 8.1 Changing area of farmland



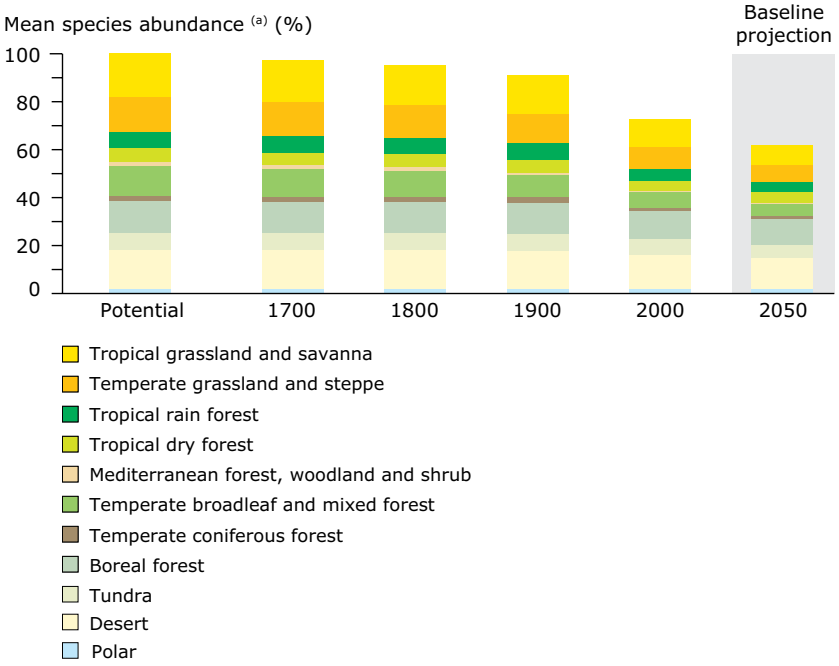
Source: OECD, 2008.

Map 8.2 Water erosion risk



Source: PBL, 2008.

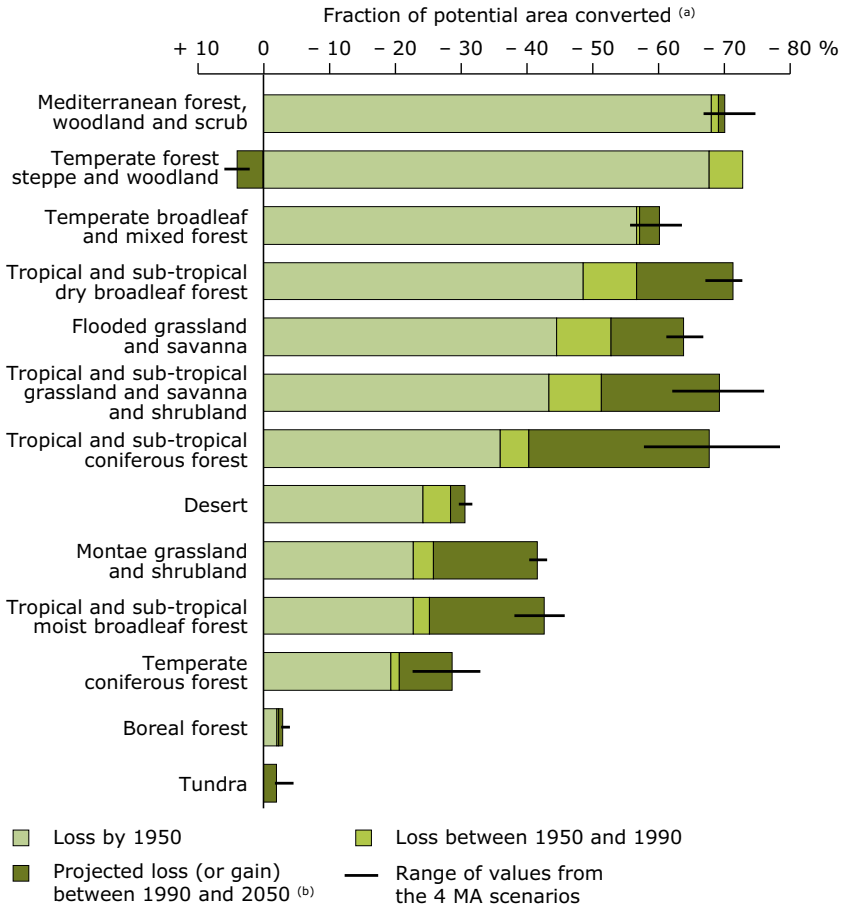
Figure 8.2 Loss of species diversity in the world biomes



Note: (a) Mean species abundance (MSA) is an indicator of biodiversity. Combining the extent of ecosystems and abundance of selected species, it reflects the state of impacted ecosystems, compared with their pristine, unimpacted state. As such it indicates how natural an ecosystem is.

Source: PBL, 2008.

Figure 8.3 Conversion of regional ecosystems (biomes)



Note: (a) The extent of different regional ecosystems (or biomes), prior to significant human impact, cannot be estimated, but the potential area of biomes can be determined on the basis of soil and climatic conditions.
(b) According to the Millennium Ecosystem Assessment (MA) scenarios. For the 2050 projections the average value of the projections under the four scenarios was plotted; the error bars (black lines) represent the range of values from the various scenarios.

Source: MA, 2005.

Box 8.1 Why is depletion of natural resources important for Europe?

In general, the loss of natural ecosystems and soil degradation damage a wide range of ecosystem services, including cycling carbon and water, and providing food and fibres. Food and water security is clearly a key concern here. The fragility of global food systems has already become apparent over recent years. Driven by recurring food and economic crises throughout 2006–2009, the number of undernourished people rose to more than one billion in 2009. The proportion of undernourished in developing countries, which was previously declining, has also risen in the past few years (FAO, 2009). Ultimately these trends may lead to regional conflicts and social instability.

Potential impacts on Europe include changes in the abundance of species, climate change, increased demand for and depletion of domestic resources (such as food and timber), and environment-induced immigration from developing countries.

Key drivers and uncertainties

More people, with greater affluence and more meat in their diets, will increase demand for agricultural production. Expansion of agricultural land is therefore likely but its extent is uncertain as it depends on population and economic growth, diet changes and technological advancement. The responses of species and ecosystems to further land conversion and intensified land use are still unknown but soil degradation and ecosystem collapses can significantly and irreversibly reduce natural production capacity.

9 Increasingly severe consequences of climate change

Accelerating climate change impacts will threaten food and water supplies, human health, and terrestrial and marine life. Europe may also see more human migration and aggravated pressure on resources supplies.

Human-induced climate change is driven mostly by greenhouse gas (GHG) emissions from fossil fuel use for energy, with deforestation and unsustainable agricultural practices also playing a role. Climate change drives environmental change more broadly, as it affects the direction and magnitude of other trends and megatrends. Aspects covered here include impacts on crop production, water availability, biodiversity and ocean acidification.

The concentration of atmospheric CO_2 has increased from about 280 parts per million (ppm) in preindustrial times to more than 387 ppm in 2008 (Richardson et al., 2009). As a consequence, the average global air temperature by 2009 had risen by 0.7–0.8 °C above the preindustrial level. Current projections suggest that global mean temperatures could rise by as much as 1.8–4.0 °C over the course of this century if global action to limit GHG emissions is unsuccessful (IPCC, 2007a).

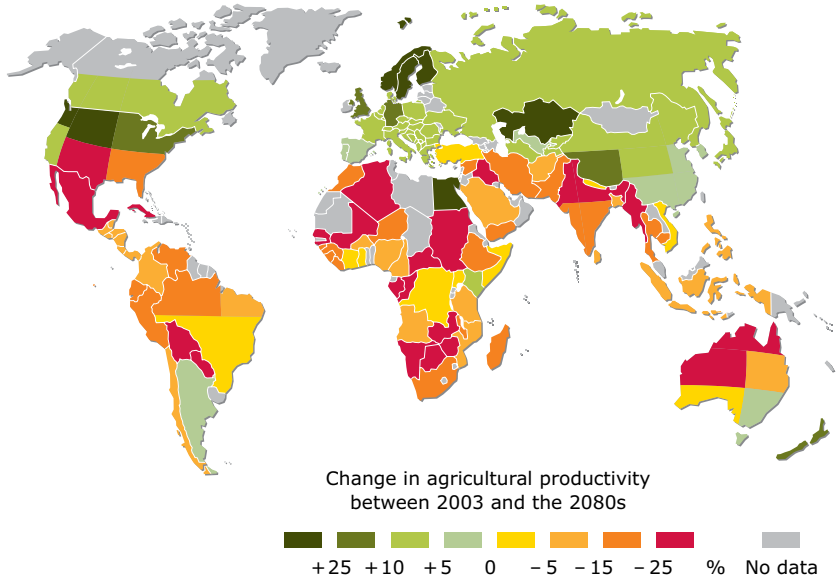
Although global crop production may increase initially (before 2030), global warming is projected to have negative effects in the long run. While production at high latitudes will generally benefit from climate change, in many African countries and Latin America it is projected to be severely compromised (Map 9.1).

Water availability in different parts of the world may be severely affected by climate change (Map 9.2). Many drylands are projected to become even drier and water demand for agriculture will increase in all regions because of greater evapotranspiration caused by higher temperatures. Furthermore, climate change may cause extreme

weather (including droughts), with greater frequency and intensity, increasing risks and uncertainty in food production.

Climate change also affects biodiversity. Boreal forest is projected to increase due to longer and warmer growing seasons. Vegetation change in low- to mid-latitudes is uncertain because transitions between tropical desert and woody vegetation types are difficult to forecast. A general increase of deciduous at the expense of evergreen vegetation is predicted at all latitudes (Map 9.3).

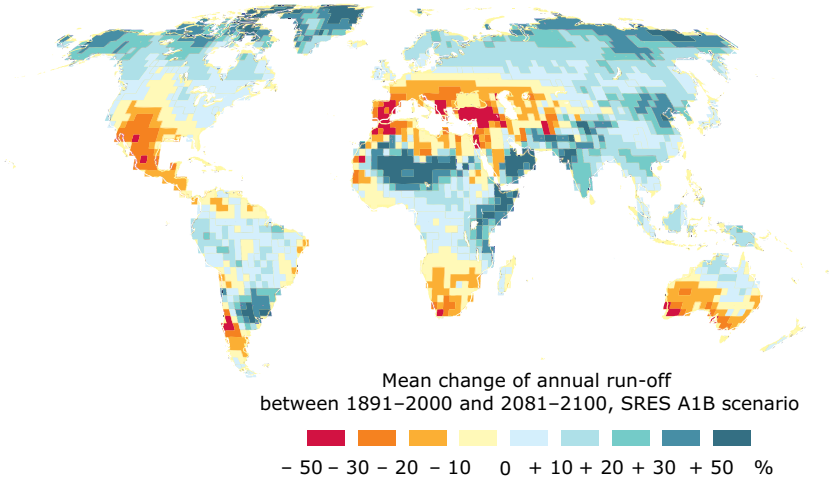
Map 9.1 Project impacts of climate change on agricultural yields



Note: The map represents the case of a business as usual scenario, and takes assumed benefits of carbon fertilisation into account. Calculations are based on the average output of six available climate general circulation models (GCM).

Source: Cline, 2007.

Map 9.2 Projected impacts of climate change on freshwater flows

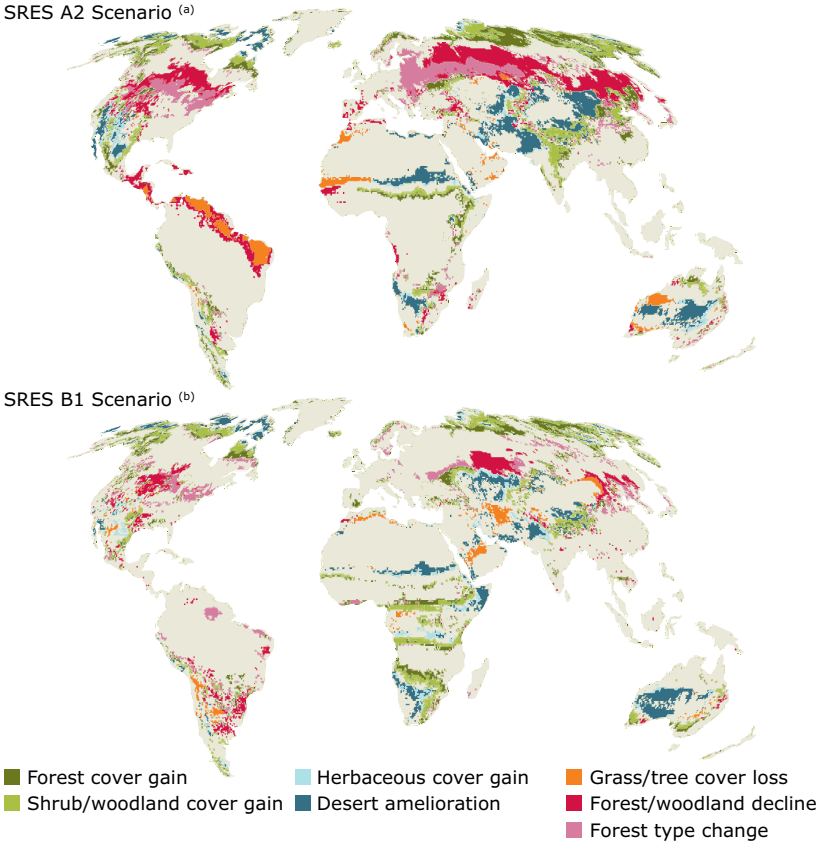


Source: IPCC, 2007b.

The increasing accumulation of CO_2 in the atmosphere is also important for marine ecosystems as its absorption in the ocean increases acidity (IPCC, 2007c) (Map 9.4). Organisms with shells and skeletons of calcium carbonate are expected to be especially vulnerable. Within 10 years, 10 % of the Arctic Ocean may become corrosive to aragonite, potentially damaging the skeletal structures of pteropods (free-swimming pelagic snails) and bottom-dwelling shellfish, which are crucial to the Arctic food web (Steinacher et al., 2009; Feely et al., 2004; Orr et al., 2005; Fabry et al., 2008; Comeau et al., 2009). Coral species are also heavily threatened and may disappear regionally by the end of this century (WGBU, 2006; Guinotte et al., 2006).

Map 9.3 Project impacts of climate change on terrestrial ecosystems

The projections only take changing climate constraints into account. Actual vegetation changes will also depend heavily on human land use.



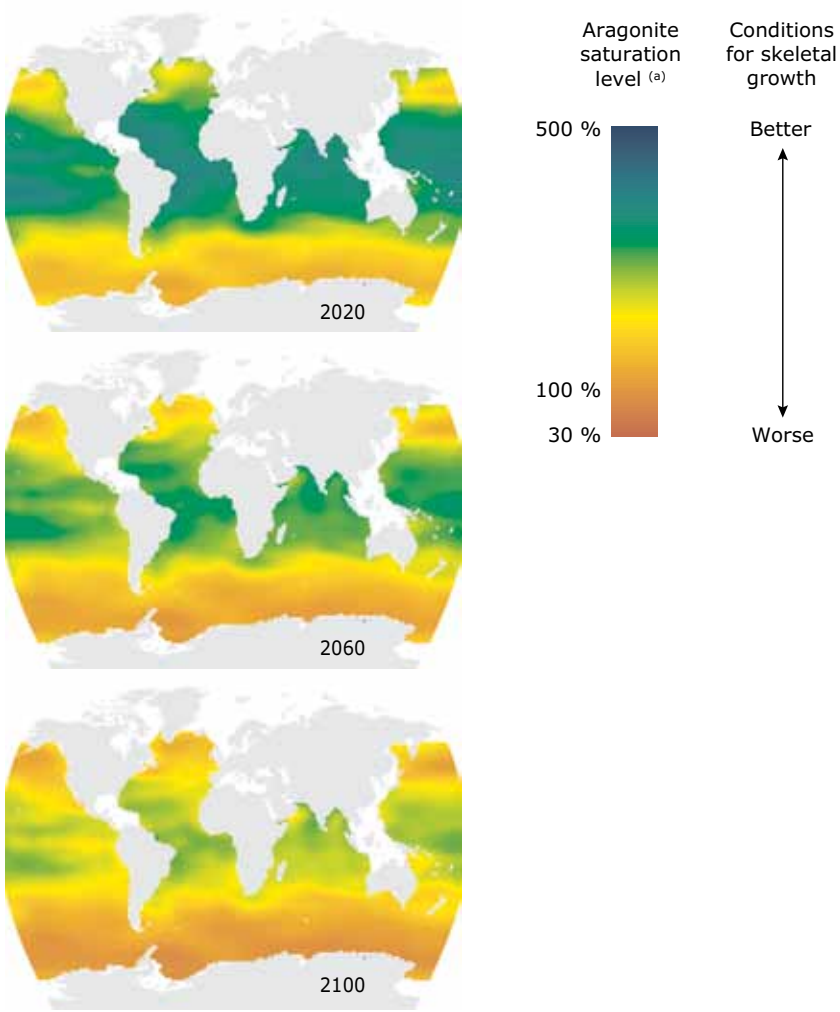
Note: IPCC Special Report on Emissions Scenarios (SRES):

(a) The A2 Scenario depicts a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies.

(b) The B1 Scenario depicts a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development.

Source: IPCC, 2007b.

Map 9.4 Projected ocean acidification by 2100



Note: (a) Aragonite is a form of calcium carbonate used by organisms such as corals, molluscs and some plankton species to build up skeletal structures and shells. Aragonite saturation levels go down as the ocean water acidifies. A value below 100 % indicates undersaturation, meaning that aragonite structures would dissolve. Lowering values imply that it becomes increasingly difficult for the mentioned organisms to survive and grow.

Source: IPCC, 2007c.

Box 9.1 Why is the growing severity of climate change impacts important for Europe?

Climate change influences the Earth's surface temperature, the sea level and the amount, timing and intensity of precipitation. On land, these changes affect freshwater availability and quality, surface-water run-off and groundwater recharge, and the spread of water-borne disease vectors. Extreme weather conditions have an increasingly large impact on vulnerable human communities, particularly the world's poor. Climate change can severely affect human health, food production, security and resource availability.

The major impacts of climate change may only become visible several decades from now but it is expected to become more important relative to the other megatrends towards the latter part of the 21st century. Projected climate change will have far-reaching impacts in Europe. It will affect the vulnerability of European society to an array of threats to human health, almost all economic sectors, ecosystem goods and services, and biodiversity. Pronounced consequences are expected in the Mediterranean basin, north-western Europe and the Arctic. Many coastal zones, mountains and areas prone to river floods are particularly vulnerable, as are urban areas. New opportunities may arise in some sectors and regions. However, with increases in both temperatures and the frequency and intensity of extreme weather events, adverse effects are likely to dominate in the medium to long term.

Key drivers and uncertainties

Increases in GHG emissions are largely due to the use of fossil fuels, although deforestation, land-use change and agriculture also provide significant but smaller contributions. Major drivers are therefore global population growth, increases in demand for food, water and energy, and agricultural practices. Policy responses, both mitigation and adaptation, are crucial.

The uncertainties regarding GHG emissions and ecosystem responses (including tipping points) are considerable. Major uncertainties also remain about impacts on human society, including long-term health effects, regional conflicts, migration and political instability.

10 Increasing environmental pollution load

An increasingly complex mix of pollutants threatens the Earth's regulatory mechanisms. Particulates, nitrogen and ground-level ozone merit particular attention because of their complex and potentially far-reaching effects on ecosystem functioning, climate regulation and human health. In addition, many other chemical substances are released into the environment, with effects — in isolation or combined — that are still poorly understood.

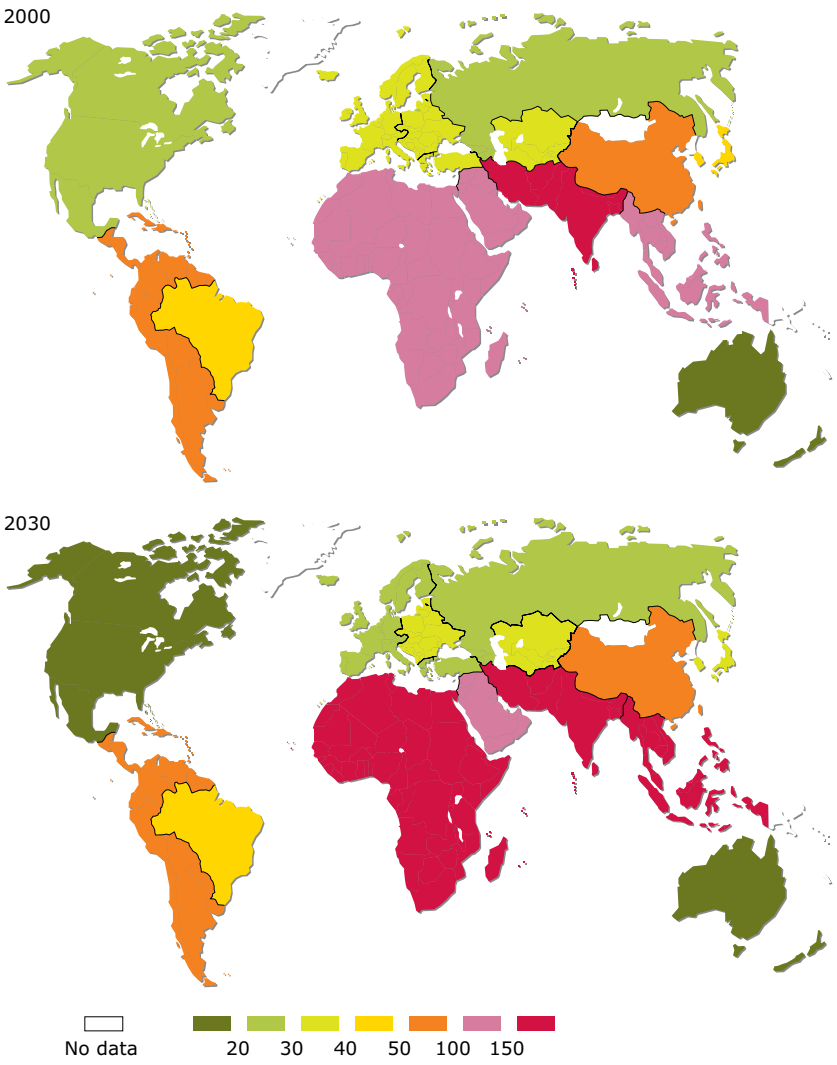
Over recent centuries, humanity's impact on the environment has risen steadily alongside population growth. Initially, effects on air and (drinking) water quality were primarily felt locally. But the last few decades have witnessed more and more regional impacts (such as acid rain) and many problems already have a global impact (for example climate change and stratospheric ozone loss). The mix of pollutants and their effects (in isolation or combined) has grown more and more complex, with environmental feed-backs becoming apparent at ever wider scales. The term 'anthropocene' has been suggested to describe the current era — a period in which human resource use has become a dominant driving force, shaping the Earth and its regulating mechanisms (Crutzen, 2002).

Four environmental pollution subtrends that merit particular attention in view of their complex nature and potentially far-reaching effects are highlighted below. They share most of the same drivers (for instance industrialisation, globalisation and rising consumption) and contribute to the general deterioration of ecosystems and human health.

Particulate matter

Apart from emitting greenhouse gases, fuel burning for heating, industry and transport also leads to pollution of the air with small particles (PM_{10} — particulate matter up to 10 micrometres in diameter) (Map 10.1). Urban haze or rural smoke can ultimately become transcontinental plumes of atmospheric brown clouds. These brown clouds consist of sulphate, nitrate, hundreds of organic chemicals, black carbon, soil dust, fly ash and other aerosols (Ramanathan and Feng, 2008). This type of pollution is projected to increase, particularly in rapidly developing countries. Although atmospheric brown clouds have so far been a predominantly Asian phenomenon, long-distance transport to other parts of the world can occur. Recently, an SO_2-rich pollution plume of east-Asian origin was detected over Europe, having travelled across the north Pacific, North America and the north Atlantic in only eight to ten days (Fiedler et al., 2008).

Map 10.1 Particulate matter pollution



Note: (a) PM_{10} is particulate matter 10 micrometres in diameter, or less.

Source: OECD, 2008.

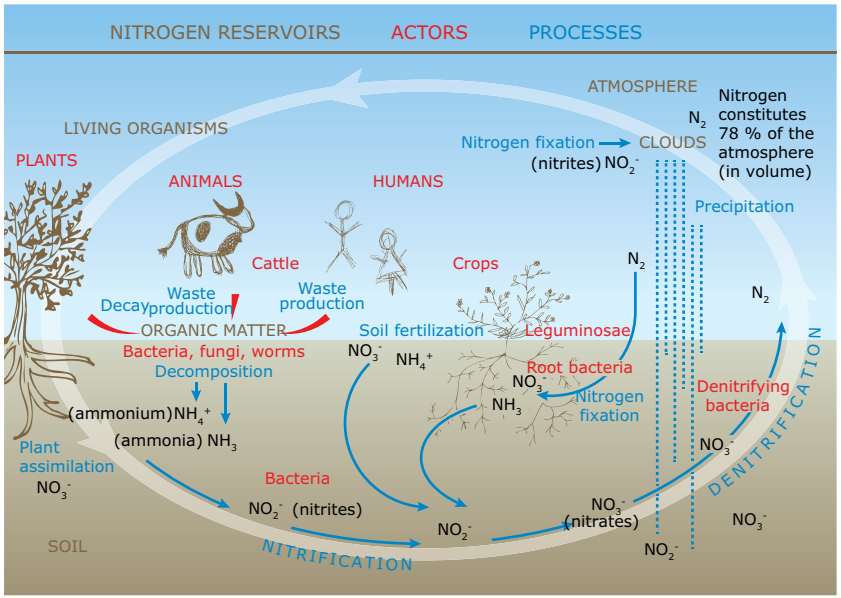
Reactive nitrogen (6)

Nitrogen makes up almost 80 % of the atmosphere in the form of N_2 gas. This nitrogen is only available to plants if it is 'fixed' into reactive forms. Natural fixation in the atmosphere and in the soil is supplemented by cultivation of N-fixating crops, such as rice and legumes, and by industrial production of nitrogenous fertiliser. Fossil fuel combustion, emitting large additional amounts of NO_X, increases the load of reactive nitrogen even further (Figure 10.1). The total production of reactive nitrogen in the environment has more than doubled as the result of these human activities, causing eutrophication of terrestrial and aquatic habitats (Galloway et al., 2003).

The total amount of reactive nitrogen is expected to increase further in line with food production and fossil fuel use. In a baseline projection, total inputs of reactive nitrogen to agricultural land are expected to increase by about 20 % by 2050, with the highest absolute levels in Asia (Figure 10.2). The global quantity of reactive nitrogen exported by rivers to coastal marine systems is projected to increase by about 4 % by 2030, with a decrease in OECD countries of about 5 % overshadowed by an 11 % increase in the BRIC (Brazil, Russia, India, China) countries.

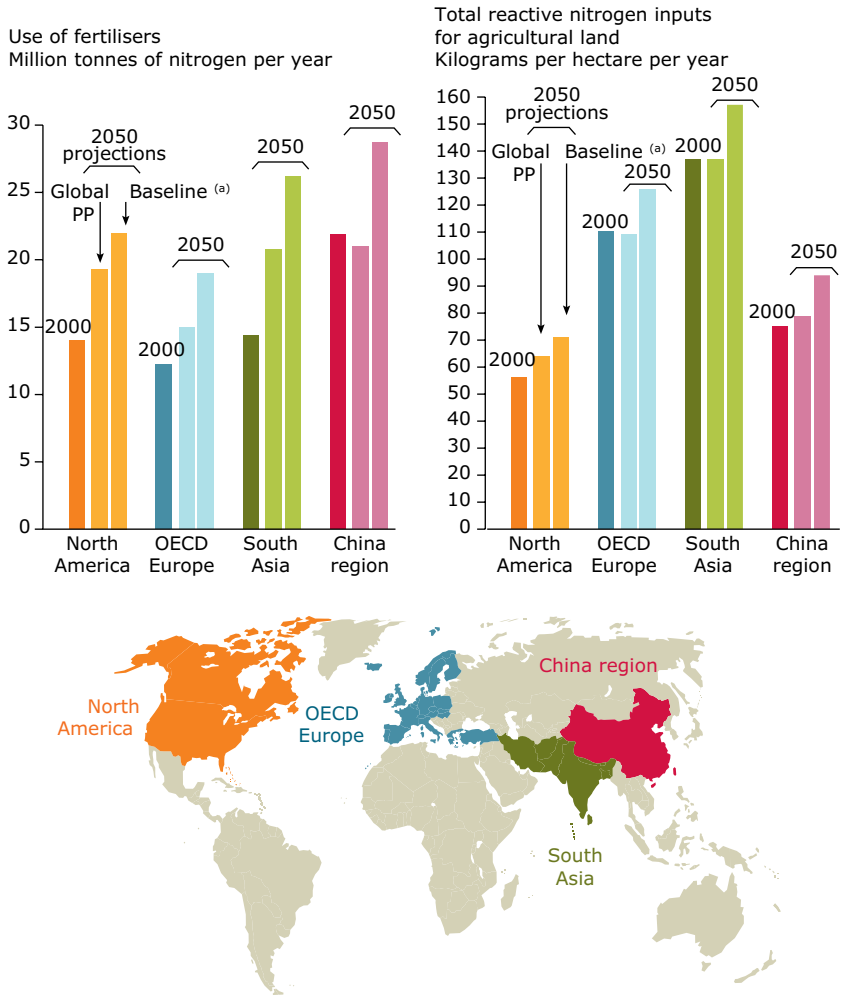
(6) Reactive nitrogen (Nr) includes: inorganic reduced forms of N, such as ammonia (NH_3) and ammonium (NH_4^+); inorganic oxidised forms such as nitrogen oxide (NO_X), nitric acid (HNO_3), nitrous oxide (N_2O) and nitrate (NO_3^-); and organic compounds such as urea, amines, proteins and nucleic acids (PBL, 2010).

Figure 10.1 The nitrogen cycle



Source: Adapted from Ritter, 2006.

Figure 10.2 Use of fertilisers and total reactive nitrogen inputs on agricultural land



Note: Baseline and global policy package (PP) scenario.

(a) Global PP is a scenario assuming the worldwide development of environmental policies addressing climate change, air pollution, water and agriculture. The baseline is a business-as-usual scenario.

Source: OECD, 2008.

Ground-level ozone

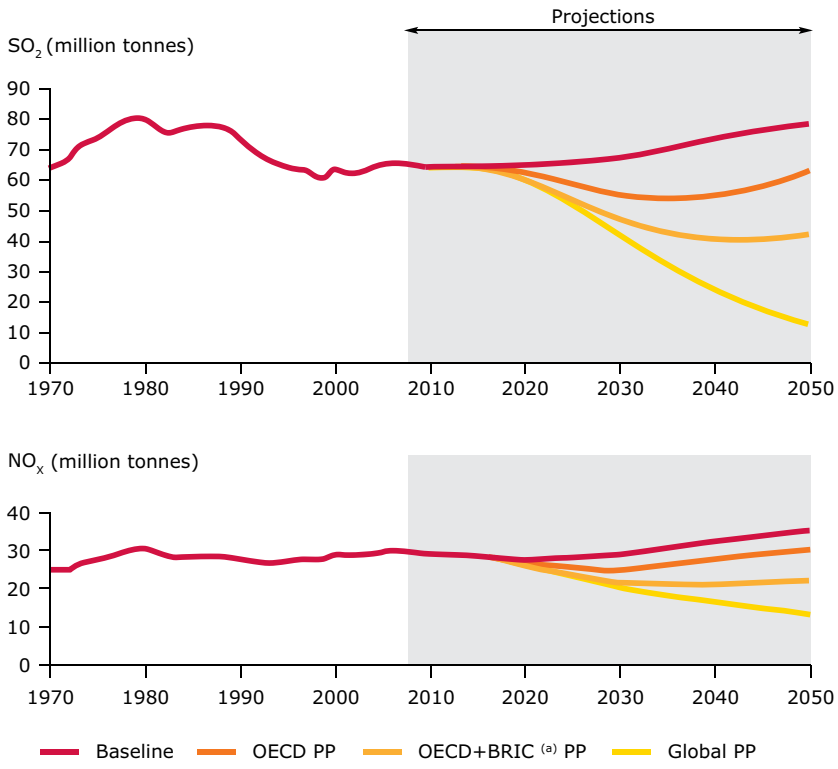
Ground-level (tropospheric) ozone acts as a greenhouse gas and also affects primary plant production and human health. Background tropospheric ozone concentrations in the northern hemisphere have doubled since the industrial revolution as a result of anthropogenic emissions of a range of ozone precursors, including nitrogen oxides (NO_X), non-methane volatile organic compounds, carbon monoxide (CO) and methane (CH_4). Agriculture and burning fossil fuels in industry and transport are the main sources of these emissions. Air quality modelling indicates that ozone ground-level concentrations may increase further regionally, particularly in Asia, Africa and South America. Whereas NO_X and CO emissions may stabilise or decrease as a result of technical advances and policy measures, methane emission is projected to almost double by 2100 (Royal Society, 2008). The uncertainty is high, however, and the adoption of policy measures can modify the emission trends to a considerable degree (Royal Society, 2008; OECD, 2008; PBL, 2008; see also Figure 10.3).

Chemicals

We are burdening the environment with a rapidly expanding and increasingly complex pollutant load, with potential effects on public health and the environment that are poorly understood. An estimated 70 000 to 100 000 chemical substances are commercially available and this number is rapidly expanding. Almost 5 000 of these substances are produced in volumes exceeding one million tonnes a year. OECD countries are the biggest producers of chemicals, but output is increasing more than twice as fast in India, China, Brazil, South Africa and Indonesia. The economic share of these countries in total world chemical production is projected to rise to around 30 % by 2020 and almost 40 % by 2030 (OECD, 2008) (Figure 10.4).

Some environmental aspects of chemicals, such as toxicity and eco-toxicity, exposure and emissions, are regulated by legislation on issues such as pesticides, biocides and radioactive substances. Contrastingly, the EU REACH Regulation (2007) provides a comprehensive approach to industrial chemicals in manufacturing and products.

Figure 10.3 Emissions of selected air pollutants



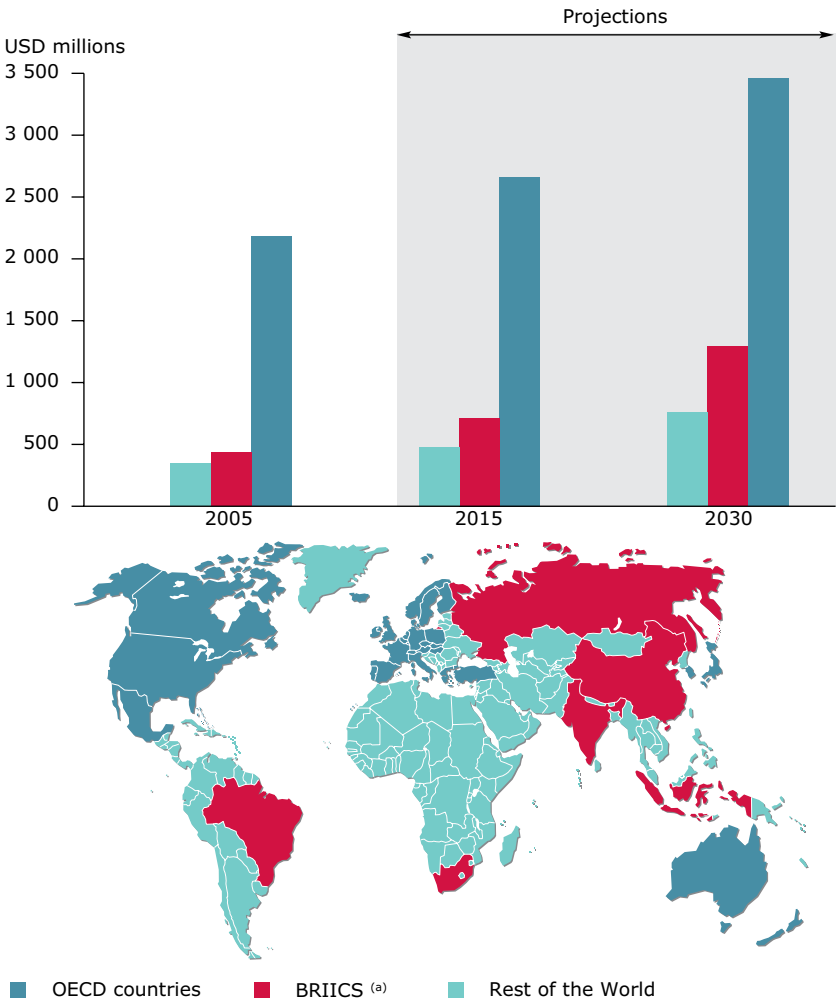
Note: The OECD Environmental Outlook simulated three environmental policy packages (PP) addressing four issues (agriculture, climate change, air pollution and water quality), applied to specific groups of countries and at a global level.

- The OECD PP would result from applying the following policies to OECD countries: carbon taxes, a substantial reduction in air pollution and improved sewage systems.
- The OECD+BRIC PP would result from applying the same policies to OECD and BRIC countries, adding deregulation of agriculture (cutting subsidies and tariffs).
- The Global PP would involve applying all these policies worldwide (with delayed target for low income countries).
- The baseline is a no-new policies scenario (or business-as-usual). It is not the most plausible future development but a good benchmark for comparison.

(a) Brazil, Russia, India and China.

Source: PBL, 2008; OECD, 2008.

Figure 10.4 Production of chemicals



Note: (a) Brazil, Russia, India, Indonesia, China, South Africa.

Source: OECD, 2008.

Box 10.1 Why is this increasing pollution load important for Europe?

Particulate matter seriously endangers human health, particularly in urban areas. It can also impact the climate and affect crop and water security. In Europe, pollution with fine particles ($PM_{2.5}$ — smaller than 2.5 micrometres) is associated with approximately 500 000 premature deaths per year at present.

Nitrogen pollution affects the atmosphere by depleting stratospheric ozone. It also affects groundwater quality and leads to eutrophication of freshwater and marine ecosystems. After applying manure and fertilisers to agricultural land, excess nutrients may be emitted to the air or leak as nitrate into ground water or run off to surface water. This freshwater pollution load is ultimately discharged to coastal waters, where it accelerates the growth of phytoplankton. It can change the composition and abundance of marine organisms and ultimately lead to oxygen depletion, killing bottom-dwelling organisms. Oxygen depletion has risen sharply over the past 50 years, from about 10 documented cases in 1960 to at least 169 in 2007 worldwide. It is expected to become more widespread with increasing sea temperatures induced by climate change (Selman et al., 2008).

The current ground-level ozone concentrations in industrialised regions of North America, Europe and Asia can reduce yields of staple crops by as much as 10–20 %.The productivity and species composition of natural habitats may also change, putting biodiversity at risk, particularly in south-east Asia, South America, central Africa, the eastern USA and western Europe. The raised ozone levels in North America and Europe are also associated with respiratory and cardiovascular problems and increased mortality. There is increasing evidence that long-term chronic exposure has adverse effects on lung function. Health impacts have been observed at ambient concentrations of approximately 35 ppb and below the current WHO guideline of 50 ppb (for a daily eight-hour average concentration). The number of premature deaths due to ground level ozone worldwide is expected to quadruple by 2030 (OECD, 2008).

Chemicals may be toxic and affect human health and ecosystem functioning in many ways, although uncontested evidence for toxicity remains limited to only a few hundreds of the most traded substances. The effects of very persistent chemicals are particularly difficult to assess. Long-term low-dose exposure to these substances may have subtle but serious effects. Exposure to neurotoxic chemicals, for example, has been associated with mild neuro-developmental disorders in children (Grandjean and Landrigan, 2006).

A further concern is that traditional toxicological assessment is normally undertaken only on individual chemicals. The toxicity of the breakdown products is less certain and the overall impact of the cocktail of chemicals on ecosystem structure and function (especially in marine and freshwater ecosystems) and on human health is unknown and hard to test for adequately (VKM, 2008; Carpenter et al., 2002). Recent research points to the risks of pharmaceuticals accumulating in the environment. These substances may have strong environmental effects, since they are specifically designed to affect biological functioning. The presence of hormone-mimicking substances in water, for example, has been linked to the feminisation of fish (EEA, 2010e).

Key drivers and uncertainties

Economic and population growth cause increasing emissions of reactive nitrogen, ozone precursors and chemical waste. Climate change and land use changes may influence the emissions from natural sources. Increased demand for energy, transport, food and non-food crops may further increase emissions arising from human activity and changes in consumption and production patterns are likely to affect the distribution of pollutants. Legislation and technology may, however, help decouple pollution from economic growth.

Key uncertainties concern the actual impacts of different pollutants on health and ecosystems, as well as their compound effects. The possible effects of nitrogen, ozone and particulate matter on climate change represent a complex cross-cutting issue with many uncertainties, notably with respect to consumer behaviour, risk awareness, technology developments and policy responses.

11 Environmental regulation and governance: increasing fragmentation and convergence

The world is devising new governance models, including multilateral agreements on numerous issues and public-private ventures. In the absence of global regulation, advanced European standards and procedures have often been adopted worldwide. But will this situation continue in the future?

Global regulation and governance increasingly extends beyond law-based multilateral international treaty regimes and organisations to include alternative modes. Four distinct but interrelated trends are apparent:

- increasing regional cooperation and integration;
- the growing importance of groupings of leading countries such as the G8 and G20;
- increasingly diverse approaches to regulation and a stronger role for softer forms of policy coordination (i.e. guidelines, frameworks and codes);
- the growing relevance of non-state actors and hybrid forms of public-private governance.

These trends are accompanied by increasing globalisation of administrative law and concerns about the legitimacy, credibility and accountability of new approaches to global regulation and governance (Grevi, 2010). However, it remains highly uncertain how the trends will develop in practice.

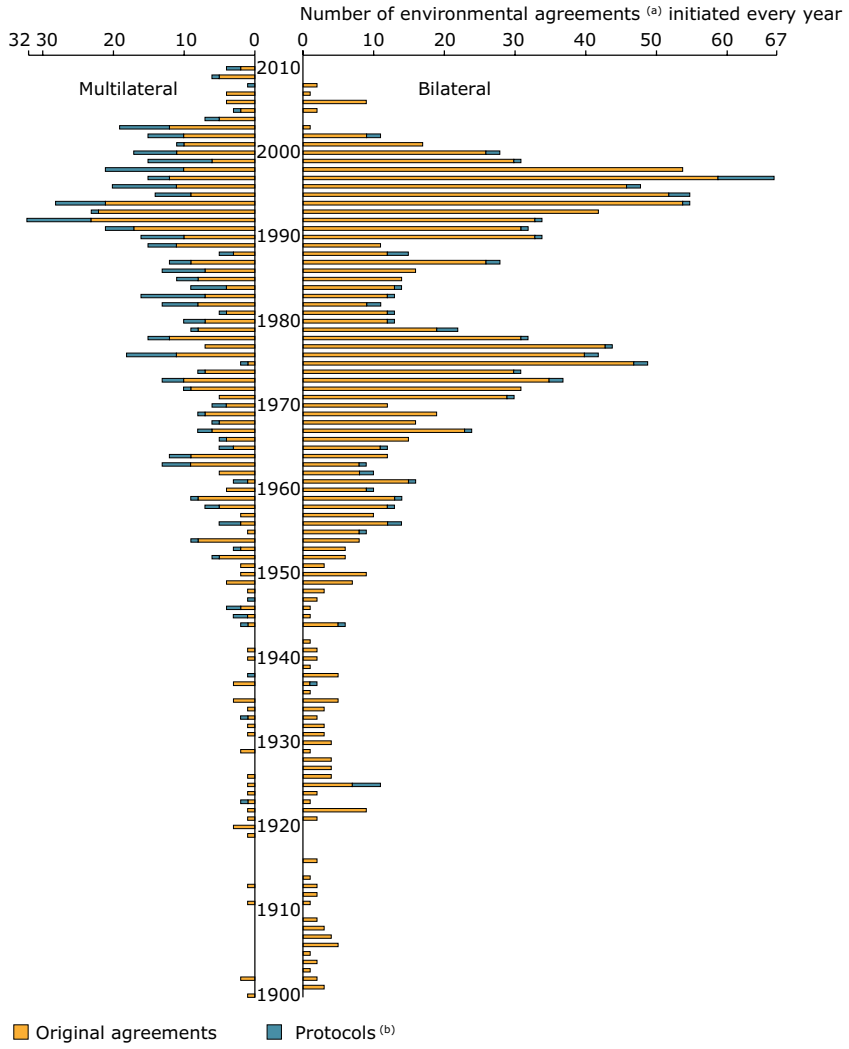
The proliferation of multilateral environmental agreements has been a key trend of recent decades (Figure 11.1). The 1990s saw a peak in the

number of multilateral organisations and treaties agreed, including the World Trade Organization (1994), the Kyoto Protocol (1997), the International Criminal Court (1998) and the UN Millennium Declaration (2000). However, this drive has eased since then. Global negotiation processes such as the Doha Development Round of the WTO and talks on a follow-up to the Kyoto Protocol have become more complex. There has, however, been some progress towards closer cooperation in many regions, most notably east Asia. Countries increasingly collaborate to bring down trade barriers, harmonise product standards and to equalise production requirements such as environmental regulations (Crawford and Fiorino, 2005) (Figure 11.2). This is likely to continue. The EU continues to be the first mover, followed by blocs such as NAFTA and ASEAN plus three (APT).

Global regulation is likely to continue and extend to new areas, given the persistence of old global challenges and the emergence of new ones. However, the way in which regulation is agreed is evolving. Over recent years policymaking and coordination has increasingly shifted from the UN umbrella to informal groupings of leading countries, such as the G8 or G20. Regulation of the financial markets is being strengthened under the revision of the banking supervision accords (also called Basel III) by the Basel Committee on Banking Supervision (made up of G20 member countries and major banking countries such as Switzerland, Hong Kong and Singapore) to prevent a repetition of the financial crisis of 2008–2009, for example. Similarly, the BRIC countries now meet in a specific summit format. Beneath this proliferation of summit meetings is a trend towards 'functional' or 'messy' multilateralism: ad hoc coalitions of relevant countries willing to address a specific challenge (Haass, 2010).

Another major trend often goes unnoticed yet it is highly relevant and likely to shape future regulation: the globalisation of administrative law. While the processes of legislating are becoming increasingly fragmented and diverse, there is increasing uniformity and integration in norms and standards (for example with respect to environmental impact assessment, which is covered by International Organization for Standardization (ISO) Standard 14011).

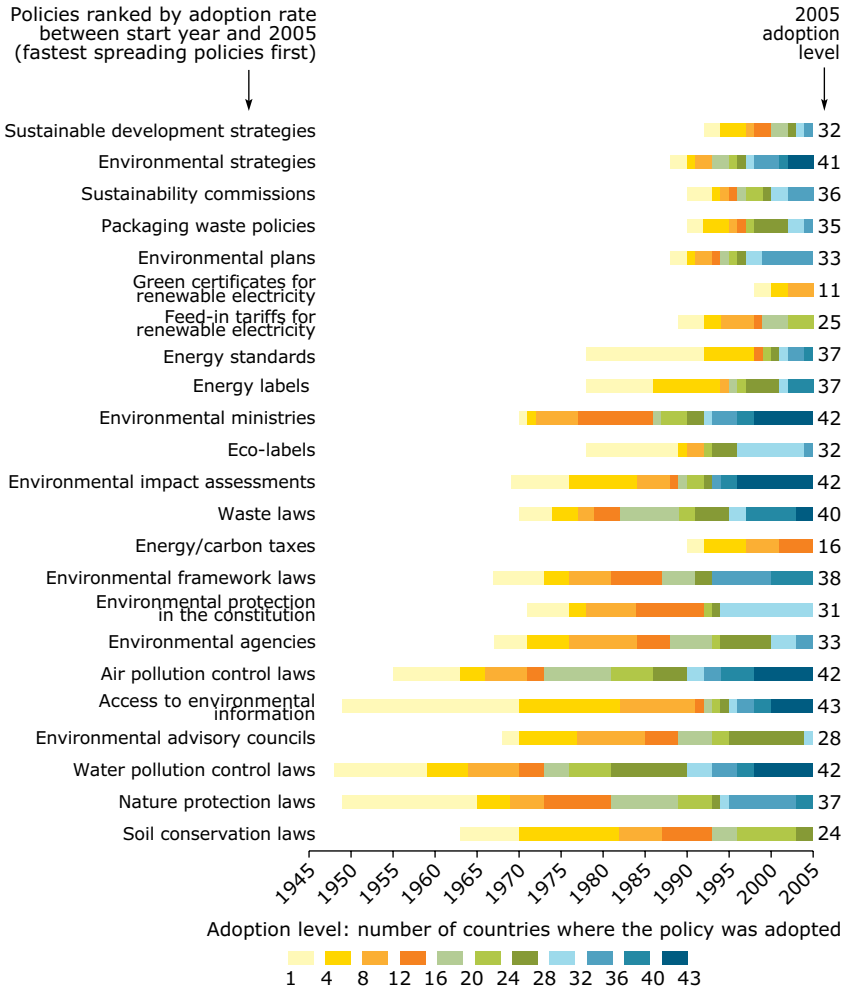
Figure 11.1 International environmental agreements since 1900



Note: (a) Environmental agreements are understood here as intergovernmental legally binding documents with a primary stated purpose of preventing or managing human impacts on natural resources.
(b) Protocols modify and strengthen existing agreements.

Source: Mitchell, 2010.

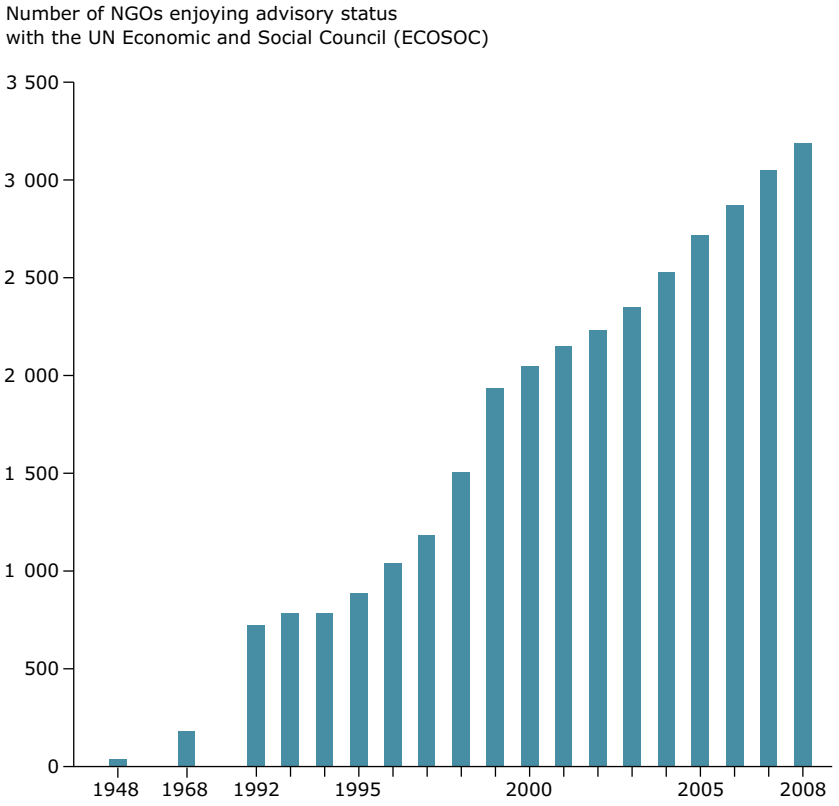
Figure 11.2 International spread of environmental policies across 43 OECD and Central and Eastern European countries



Note: Countries included in the study: Albania, Australia, Austria, Belarus, Belgium, Bosnia, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Germany, Estonia, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Japan, Latvia, Lithuania, Luxembourg, the former Yugoslav Republic of Macedonia, Moldova, New Zealand, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Sweden, Switzerland, Spain, South Korea, Turkey, Ukraine, the United Kingdom, USA.

Source: Busch and Joergens, 2005.

Figure 11.3 Growing relevance of non-state actors



Source: ECOSOC, 2008.

Principles of good governance are widely accepted across the world, both in public and corporate settings, and many have been informed by environmental law. Norms and standards can be highly effective even if they are non-binding. These 'softer' versions of policy coordination are increasingly complemented by bilateral policy learning and voluntary action. Diffusion of best regulatory practice between nation states is gaining speed as a consequence (Busch and Joergens, 2005). More often than not it leads to increasing convergence of policies and standards at the national level, despite worries about the absence of progress in international negotiations.

International policy processes are increasingly influenced by private actors, such as transnational corporations or non-governmental organisations, which represent essential sources of information and knowledge. While the nation state is likely to remain the overall dominant source of political power and authority, making and implementing transnational norms and rules is increasingly shared with non-state actors — a process terms 'co-regulation' (Falkner, 2008).

Global public-private partnerships are expected to grow in importance, covering a broader spectrum of issues such as standard setting, law enforcement and development aid (Andonova, 2010). The rise of these hybrid forms of global governance is also linked to the spread of concepts such as privatisation and deregulation, and the desire to mobilise private capital. However, private-private partnerships (without the involvement of governmental actors or international organisations) are important as well. Private actors such as transnational companies increasingly establish and monitor their own regulations based on shared norms and principles as well as roles and responsibilities.

The increasing role and relevance of non-state actors also gives rise to concerns about accountability and legitimacy. Setting and applying rules and standards by international bodies with no legislative authority increasingly places obligations on national legislators who are not represented in these processes. Furthermore, NGOs are often concerned that they are not given a proper hearing by corporate actors who then dominate decision-making. In recent years there have been growing calls for more balanced participation by non-state actors, greater transparency and clear procedures, with continuing pressure on public and corporate decision-makers nationally and internationally.

New forms of cooperation are not likely to be a full alternative to the classic multilateral approach of international decision-making, and the calls for reforms of existing global governance structures are likely to intensify (Biermann et al., 2009). Pressure to better integrate and represent emerging economies in global institutions and processes is unlikely to wane. Different democratic traditions, preferences and interests are expected to challenge the western norms and values that underpin much of the existing global system of governance (Grevi, 2009).

Box 11.1 Why is global regulation and governance important for Europe?

In the past, Europe has often benefited from the globalisation of regulatory standards that resembled its own advanced standards. Further developing international regulation can allow Europe to maintain its relatively advanced sustainable development policies without losing its competitive edge in global markets. Harmonising standards may have a positive effect on the sustainability of foreign production practices worldwide, for example by increasing diffusion of resource-efficient, low-carbon technologies. Europe, as a major importer bloc, can insist on sustainability in its trade relations. However, the positive effects of increased trade depend on the effectiveness of Europe's own environmental policies. If weak then the removal of trade barriers could simply boost Europe's economy, increase the impact on natural resources and the environment.

Many observers fear that the EU could wield less global influence in the future due to economic power shifts and barriers to coordinated action. The latter include the rules of participation in international organisations (i.e. regarding whether the Commission or the Council should represent the Union), the time needed for internal coordination, and disputes about shared competencies (among Member States, the EU Council and the European Commission).

Progress in international negotiations may continue to stall. Current changes in global governance mechanisms will make it a hard to design policies to represent European interests in formal and informal international forums. It demands new approaches to enhance joint policy formulation in areas such as trade, environment, development aid, technology, and defence and security.

Key drivers and uncertainties

Economic globalisation is continuing and will further expand. The ratio of global exports to global GDP rose from 5.5 % to 19.4 % in the period 1950–2005. Trade barriers and different standards hamper growth and thus pressure to harmonise regulations is likely to continue alongside the regional and global integration of markets. Rapid economic growth in emerging economies, changing resource scarcity patterns and the growing impacts of climate change will create demands for global and regional regulation in the areas of economics, trade and the environment. The role and relevance of leading country gatherings such as the G8, G20 and G77 are likely to increase.

Dissatisfaction with progress in international negotiations in key areas such as trade and environment is likely to drive an increased focus on regional integration. Governments will need non-state actors to help with policy formulation and implementation as their own resources will be inadequate.

Uncertainty marks this megatrend at every turn. Major uncertainties relate, for example, to the continuation of current economic growth patterns globally and the impacts of the recent financial and economic crisis. How emerging economies' institutions perform and how their democracies develop is another key uncertainty as both affect economic growth and international negotiation processes. Many emerging economies are undergoing fundamental socioeconomic change in a much shorter time than developed economies did, while their governance remains inadequate. Global governance developments will also be heavily influenced by the extent to which citizens press for participation, transparency and accountability in global negotiations. The effectiveness of soft approaches to global policy coordination depends hugely on policy implementation at home, which faces its own problems.

Links between global megatrends and Europe's environmental challenges

Dedicated management of natural capital and ecosystem services emerges as a compelling integrating concept for managing the links between global drivers and the four priorities of the EU's 6th Environment Action Programme.

The SOER 2010 (EEA, 2010f) emphasises four sets of key environmental challenges: climate change, biodiversity loss, growing material resource use and continuing concerns related to environment, health and quality of life.

While providing detailed assessments of each of the four overarching environmental challenges and related environmental issues, SOER 2010 also stresses the importance of links between environmental challenges. The global megatrends presented in the preceding chapters imply a variety of additional social, technological, economic, environmental and political factors beyond Europe's control that are already affecting the European environment and are expected to continue doing so.

Amid this complexity, the notion of dedicated management of natural capital and ecosystem services emerges as a compelling integrating concept for managing these multiple challenges effectively. Climate change is an obvious challenge. The EU has reduced its greenhouse gas emissions and is on track to meet its Kyoto Protocol commitments. However, global and European cuts in greenhouse gas emissions are far from sufficient to keep average world temperature increases below 2 °C. A whole set of global socioeconomic megatrends influence climate change mitigation and the severity of impacts in Europe. Projected direct impacts include biodiversity change, particularly in the Arctic, the Alpine region and the Mediterranean. Water scarcity is projected to become more pronounced in many southern European rivers, while coastal and river flooding problems are likely to increase as well.

Global megatrends and EU environmental policy priorities

Source: EEA, 2010f.

Europe may experience increased migration pressures from developing countries where global environmental change becomes more important as a driver of resettlement. Many of the countries that are most vulnerable to climate change are outside Europe, although some are our direct neighbours. Often these countries are highly dependent on climate-sensitive sectors such as farming and fishing.

The links between climate change, poverty, and political and security risks and their relevance for Europe are numerous. Climate change is expected to affect habitat and species distributions and to exacerbate biodiversity loss. Europe has established an extensive network of protected areas and programmes to reverse the loss of endangered species. However, widespread alteration of landscapes, degradation of ecosystems and loss of natural capital have meant that the EU has not met its target of halting biodiversity loss by 2010.

The increasing spread of invasive species and the impacts on coastal, Mediterranean, Alpine and Arctic habitats are of particular concern. Although oil production is declining in EEA countries, intensifying off-shore drilling in Europe (and also in particularly sensitive areas like the Arctic) poses increasing risks to the marine environment. Ecosystems are additionally affected by transboundary pollution effects, notably the increase of ground-level ozone, persistent organic pollutants (POPs) and particulate matter that result from increased emissions outside Europe. Its reliance on global ecosystems will increase Europe's vulnerability to environmental degradation elsewhere.

Biodiversity has also continued to decline globally despite a few encouraging achievements. The global rate of species extinction is escalating and is now estimated to be 1 000 times the natural rate (IUCN, 2010). Evidence is growing that critical ecosystem services are under great pressure globally (MA, 2005).

Loss of biodiversity in other regions of the world affects European interests in several ways. The world's poor are most severely impacted by biodiversity loss as they are usually most directly reliant on functioning ecosystem services (TEEB, 2009). Increased poverty and inequality are likely to fuel conflict and instability in regions already characterised by fragile governance structures. Moreover, reduced genetic variety in crops and cultivars implies future losses of economic

and social benefits for Europe in such critical areas as food production and modern healthcare (CBD, 2010).

In Europe, resource use continues to rise. The EU-27 average annual use of material resources is some 16 tonnes per person. Demand for materials has long exceeded Europe's ability to generate what it needs; 20–30 % of resources used are imported. Europe is resource-poor for fossil fuels (oil and gas) and minerals (e.g. rare earths, phosphorus) and will largely remain dependent on supplies from abroad.

Global extraction of natural resources from ecosystems grew more or less steadily over the past 25 years, from 40 billion tonnes in 1980 to 58 billion tonnes in 2005. Resource extraction is unevenly distributed across the world, with Asia accounting for the largest share in 2005 (48 % of total tonnage, compared with Europe's 13 %). Over this period, a partial decoupling of global resource extraction and economic growth took place: resource extraction increased by roughly 50 %, whereas world economic output (GDP) rose about 110 % (SERI, 2009). Nonetheless, resource use and extraction is still increasing in absolute terms.

Internationally, food, energy and water systems appear to be more vulnerable and fragile than thought a few years ago due to increased demand, and decreased and unstable supply. Over-exploitation, degradation and loss of soils are key concerns in this regard (FAO, 2009; IEA, 2009; WB, 2009). Global competition and increased geographic and corporate concentration of supplies for some resources together mean that Europe faces increasing supply risks (EC, 2010).

For energy Europe may turn to its own stocks (coal, oil shale, the revival of mining) but exploitation costs will be high because of the high costs of labour, environmental and occupational security, accessibility and landscape disruption. Increased use of renewable energy sources in the supply mix will help curb this problem.

Changes in the abundance of migratory species and climate change impacts may be aggravated by an increased demand for and depletion of domestic resources (such as food and timber). Similarly, increased global demand for European agricultural and forestry products may lead to an increase in the intensity and scale of agriculture and

forestry in Europe, increasing pressure on water and soil resources. Technological efficiency gains may, however, reduce pressure on Europe's natural resources.

Regarding the interplay between environment, health and quality of life, it is worth noting that water and air pollution have declined — but not enough to ensure good ecological quality in all water bodies or good air quality in all urban areas. The analysis presented in the preceding chapters indicates that global trends will also influence pollution, environment and health concerns. For example, in coming decades hemispheric air pollution is expected to increase as economies across Asia become stronger (although policies to address air pollution in China and elsewhere may reverse this trend). Hemispheric pollution by contaminants such as ozone, particulate matter or POPs is expected to contribute to the background level of air pollution across Europe, as well as increasing deposition of pollutants in water and soil. This process is likely to reverse improvements in air quality due to lower local urban emissions.

New technologies offer opportunities to reduce pollution levels and improve monitoring, but their possible impacts on the environment and health will have to be carefully examined. The production of chemicals and releases of reactive nitrogen (from fossil fuel combustion and the use of nitrogenous fertilisers) are also of increasing concern, and the impacts on Europe are still unclear.

In spite of general progress in the area of environment and health in Europe, the global human toll of environmental health impacts remains deeply worrying. Unsafe water, poor sanitation and hygiene conditions, urban outdoor air pollution, indoor smoke from solid fuels, lead exposure and global climate change account for nearly a tenth of deaths and disease globally, and around a quarter of deaths and disease in children under five years of age (WHO, 2009a). Again, poor populations at low latitudes are affected most heavily.

Many low- and middle-income countries now face a growing burden from new health risks, while still fighting an unfinished battle with traditional problems. The World Health Organization (WHO) forecasts that between 2006 and 2015 deaths from non-communicable diseases could increase worldwide by 17 %. The greatest increase is projected for the African region (24 %) followed by the eastern

Mediterranean region (23 %) (WHO, 2010). Europe is likely to face an increased problem of emerging or re-emerging infectious diseases that are critically influenced by changes in temperature or precipitation, habitat loss and ecological destruction (ECDC, 2010; Patz et al., 2008). In an increasingly urbanised world, which is tightly bound together by long-distance transport, the incidence and distribution of infectious diseases affecting humans is likely to increase (Jones et al., 2008).

Several of the global megatrends identified add more general pressure and uncertainty to the overall competition for natural resources. Ultimately, this will further increase pressure on ecosystems globally, and especially their capacity to ensure continued food, energy and water security.

According to the United Nations Food and Agriculture Organization (FAO), demand for food, feed and fibres could grow by 70 % by 2050 (FAO, 2009a). The fragility of global food, water and energy systems has become apparent over recent years. For example, arable land per person declined globally from 0.43 ha in 1962 to 0.26 ha in 1998. The FAO expects this to fall further by 1.5 % per year between now and 2030 if no major policy changes are initiated (FAO, 2009b).

Similarly, the International Energy Agency (IEA) expects global demand for energy to rise by 40 % over the next 20 years without major policy changes (IEA, 2009). The IEA has repeatedly warned about an impending global energy crisis due to rising long-term demand. Massive and continuous investments are needed in energy efficiency, renewable energies and new infrastructures to achieve the transition to a low-carbon, resource-efficient energy system that is compliant with long-term environmental objectives (FAO, 2009b; ECF, 2010).

At the global level, poverty and social exclusion are further exacerbated by ecosystem degradation and changes in the climate. Globally, efforts to alleviate extreme poverty were reasonably effective until recent years (FAO, 2009a). However, the food and economic crises from 2006 to 2009 have increased malnutrition rates around the world. The number of people affected rose, for the first time, to more than a billion in 2009 and the proportion of malnourished people in developing countries, which was declining quite rapidly, has risen.

Resource over-exploitation and changes in the climate aggravate threats to natural capital. They also affect quality of life, potentially undermining social and political stability (DCDC, 2010; WBGU, 2007). Furthermore, the livelihoods of billions of people are inevitably linked with the sustainability of local ecosystem services. Combined with demographic pressures, decreasing socio-ecological resilience can add a new dimension to the environment and security debate, as conflict around scarcer resources is likely to intensify and add to migration pressures (DCDC, 2010; IOM, 2009).

Global pressures pose a further set of concerns for security in many parts of the world, including Europe's neighbours in the southern and eastern Mediterranean as well as in sub-Saharan Africa. Global environmental change, especially climate change, can have significant implications for international security and create potential risks of conflict within countries and across borders. The impacts of global environmental change could aggravate problems of resource scarcity and access to basic services as well as changing the living conditions for many people in rural and urban regions. It is now widely understood that growing tensions over access to resources and migration could add to the existing problems of social and political stability in many countries in Europe's neighbourhood.

In short, global megatrends are increasing the vulnerability of Europe's environment. Many key drivers of change are highly interdependent and likely to unfold over decades rather than years. These interdependencies and trends, many of them outside Europe's direct influence, will have significant consequences and potential risks for the resilience and sustainable development of Europe's economy and society. Dedicated management of natural capital and ecosystem services provides one integrated approach to mitigating these risks and adapting to changes that may anyway occur. Better knowledge of the linkages and associated uncertainties will be essential in the future if we are to tackle such complex problems effectively.

Responding to global megatrends

Reflecting global megatrends in policymaking poses three related but distinct challenges. These relate to reviewing the approaches for assessing future change, embedding long-term perspectives in policy planning and decisions, and ensuring that environmental policy takes account of global links and is aligned to external policies on, for example, trade and aid.

The assessment of megatrends presented in the previous chapters highlights a range of interlinkages and interdependencies between global megatrends impacting social, technological, economic, political and environmental systems.

These megatrends increase complexity, uncertainty and risk, and accelerate the feedbacks within and between economic, social, technological and environmental systems. The growing global links also offer unique opportunities for action (IPCC, 2007a; MA, 2005; UNEP, 2007; University of Copenhagen, 2009; PBL, 2009; WWF et al., 2008; EC, 2009). But attempts to realise these opportunities face the challenge of huge time lags between action (or inaction) and effect.

Responding to global megatrends and reflecting future changes in policy is thus a challenging task. The report of the Reflection Group on the Future of Europe has emphasised how many recent global developments, such as the financial crisis or price volatilities in key commodity markets, have caught us by surprise (RGFE, 2010).

A key question emerges: how can we avoid urgent and critical global feedbacks in resource-using systems when we are very far from understanding them completely (Underdahl, 2010)? Much of the speed and scope of global environmental change has been underestimated by scientific assessments and policy appraisals, for example. Few considered that some of the key emerging economies would develop so fast and affect global demand as quickly as they have in the last decade. This leads to another key question: how are global-to-European inter-linkages and impacts best understood and included in policymaking?

A brief reflection reveals three related but distinct challenges for the future:

- reviewing assessment approaches to improve monitoring and analysis of future changes and their uncertainties;
- revising approaches and institutional arrangements to embed a long-term perspective into policy planning and decision-making;
- reflecting on further policy changes to take better account of global-to-European interlinkages and better align European external policies with environmental policies.

Below we expand on these points from in the light of practical experience in the EEA and its member countries.

Reviewing assessment approaches

Information and communication technologies have greatly advanced our ability to gather relevant information and support decision-making under varying conditions of uncertainty. Near real-time data and regular updating of indicators improve the information basis for monitoring environmental change, detecting emerging issues and planning swifter responses.

Integrating outlook-based indicators into national environmental data information and reporting systems on a more regular basis could improve their ability to deal with future changes. Some European countries — for example the United Kingdom — have started to complement broader studies on long-term futures with systems that routinely scan a wide range of academic and non-academic sources for signals of emerging changes. Such systems of horizon scanning explore both present certainties and future uncertainties, like an early warning radar. They can help discussions about early action based on early warnings from science.

All these approaches face the challenge of acceptability. Policymakers increasingly recognise the need to consider the long-term future in policy. Yet they also often turn to scientists to produce evidence, particularly where issues are complex and uncertain, searching for

the 'right' answer that cannot be challenged easily by public debate. Together with a greater scrutiny of scientific assessments through diverse stakeholders, demand will increase for greater transparency about how assessment findings and conclusions have been reached.

Even the best crafted, most transparent scientific exercise cannot escape the fact that profound uncertainties will always remain. Continuous learning and adaptation is needed. Great insights on future challenges often result from participating in the process of assessment rather than merely from the published record of their output (Mitchell et al., 2010).

Revising approaches and institutional arrangements

Often the focus of forward-looking assessments is almost exclusively on the product, neglecting process design. However, good process design and functioning institutional arrangements are as important for success as high-quality expertise and analysis.

Quite often, forward-looking assessments of global-European interlinkages suffer from being either too narrow in perspective or too broad and generic, and struggle to tackle relevant interlinkages across policy areas in a sufficiently comprehensive way. Global megatrends often cut across policy boundaries, requiring a more coordinated approach and sufficient capacities. Several EEA member countries have already introduced dedicated programmes or units to coordinate activities, develop common analytical methodologies and support stakeholder involvement, providing a rich body of experiences to learn from (Volkery and Ribeiro, 2009).

Locating a coordination body close to central government can increase political support and administrative buy-in and thus improve the conditions for effective use and follow-up in decision-making. Direct parliamentary oversight for future thinking is rare but existing examples show a potential added value in terms of greater attention on policy issues of longer-term relevance.

Reflecting on further policy changes

Achieving greater coherence in policies is a key future need but assessing environmental trade-offs between policies becomes more challenging when the global-European perspective is taken into account. Notable examples include trade-offs between policies on energy security, food security and environmental protection.

Past assessments often failed to take account of the possibility of more abrupt changes in key drivers. Scenarios of lower probability but higher impact should be considered more routinely in this regard. Achieving greater policy coherence is a long-term objective that requires further reflection and dialogue among different actors. Below we highlight some issues that illustrate a few of the challenges we face and for which there are no easy solutions at hand.

Some past successes, such as efforts to address surface water pollution or the deposition of SO_x and NO_x emissions, built on the availability of technological fixes that easily lent themselves to regulation. However, where these fixes have not been available, efforts to alter trends have often achieved results slowly. Moreover, technological fixes have frequently helped to solve one problem but created another. Future policymaking would benefit from a more integrated view on technologies, including broader assessments of potential interactions across media.

The fact that changes in other parts of the world will be felt closer to home increasingly blurs the boundaries between Europe's internal and external policies. Foreign policy, for example, can no longer be thought of in isolation from environmental policies, demanding new approaches to joint policy formulation in areas such as trade, environment, development aid, technology and defence and security. Environmental degradation, inequitable access to natural resources and transboundary movement of hazardous materials increase the probability of conflict and can pose risks to national security. Environmental security could be a major lens for the development of Europe's external policies.

Most available assessments assume that Europe will become more dependent on exporting countries for critical resources, with some of these countries characterised by high political instability. Quite

a few assessments conclude that the EU is becoming weaker in its relationship with big states, e.g. China, Russia and the USA. However, all advanced and emerging economies face problems that cannot be dealt with alone. This can play to the long-term advantage of Europe, which remains the largest economic bloc in the world, with considerable innovation power and experience in managing difficult socioeconomic transition processes.

Next steps

State-of-the-art, well structured information is essential to understand global megatrends and potential environmental consequences for Europe. Generating this information falls within the core remit of the EEA and undertaking the work behind the present study has confirmed both its considerable value and the need to continue it in the future.

The information presented here does not claim to be exhaustive or definitive but contributes a first step towards developing an improved information base for Europe's environment in a global context. It represents part of a longer-term, continuous, iterative activity. Further work will be undertaken during coming years — in particular in the run-up to the UN Conference on Sustainable Development (Rio+20) — to provide a solid information base to support policy formulation with a long-term perspective.

List of abbreviations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BRIC countries	Brazil, Russia, India and China
BRIIC countries	Brazil, Russia, India, Indonesia and China
CAP	EU Common Agricultural Policy
CBD	Convention on Biological Diversity
CIA	Central Intelligence Agency
DG ECFIN	Directorate General for Economic and Financial Affairs
EEA	European Environment Agency
EU	European Union
FAO	United Nations Food and Agriculture Organization
FDI	Foreign direct investment
G20	Group of 20: Argentina, Australia, Brazil, Canada, China, the European Union, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, Republic of Korea, Turkey, the United Kingdom, the United States of America
G8	Group of 8: Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States of America
GDP	Gross Domestic Product
GET	Global Education Trend
GHG	Greenhouse gas
HIV	Human immunodeficiency virus
ICT	Information and Communications Technology
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IZT	Institut für Zukunftsstudien und Technologiebewertung
MA	Millennium Ecosystem Assessment

NAFTA	North American Free Trade Agreement
NBIC	Nanotechnology, Biotechnology, Information technology and Cognitive science
NIC	National Intelligence Council
ODS	Ozone depleting substances
OECD	Organisation for Economic Cooperation and Development
OPEC	Organisation of the Petroleum Exporting Countries
REACH	Registration, Evaluation, Authorisation and Restriction of Chemical substances
RCEP	Royal Commission on Environmental Pollution
SOER	State and outlook of the environment report
SRES	Special Report on Emission Scenarios (IPCC)
UBA	Umweltbundesamt
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization UNFCCC United Nations Framework Convention on Climate Change
UN WTO	United Nations World Tourism Organization
WBCSD	World Business Council for Sustainable Development
WGBU	German Advisory Council on Global Change
WHO	World Health Organization
WIPO	World Intellectual Property Organization

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