THE EUROPEAN ENVIRONMENT
STATE AND OUTLOOK 2015

ASSESSMENT OF GLOBAL MEGATRENDS

European Environment Agency

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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Contents

What is SOER 2015?

The European environment — state and outlook 2015 (SOER 2015) provides a comprehensive assessment of the European environment's state, trends and prospects, and places it in a global context. It informs European environmental policy implementation between 2015 and 2020, and analyses the opportunities to modify existing policies, and the knowledge used to inform those policies, in order to achieve the European Union's 2050 vision of living well within the limits of the planet.

SOER 2015 is based on objective, reliable and comparable environmental information, and draws upon the evidence and knowledge base available to the European Environment Agency (EEA) and the European Environment Information and Observation Network (Eionet), a network of 39 European countries.

With its broad range of global, European, regional and country-level briefings, complemented by an overarching Synthesis report and this global megatrends report, SOER 2015 is an invaluable source of knowledge for all those interested and involved in improving Europe's environment.

All parts of SOER 2015 are available at: www.eea.europa.eu/soer.

Extended background assessments of the 11 megatrends are available at: www.eea.europa.eu/themes/scenarios/global-megatends.

Structure of SOER 2015

SOER 2015 Synthesis

The Synthesis will inform future European environmental policy in general and its implementation between 2015 and 2020 in particular. It includes a reflection on the European environment in a global context, as well as chapters summarising the state of, trends in, and prospects for the environment in Europe.

Global megatrends

A set of 11 briefings, which address:

- Diverging global population trends
- Towards a more urban world
- Changing disease burdens and risks of pandemics
- Accelerating technological change
- Continued economic growth?
- An increasingly multipolar world
- Intensified global competition for resources
- Growing pressures on ecosystems
- Increasingly severe consequences of climate change
- Increasing environmental pollution
- Diversifying approaches to governance.

The present report includes the 11 megatrend briefings and an introductory chapter.

European briefings

A set of 25 briefings, which address:

- Agriculture
- Air pollution
- Biodiversity
- Climate change impacts and adaptation
- Consumption
- Energy
- Forests
- Freshwater quality
- Green economy
- Health and environment
- Hydrological systems
- Industry
- Land systems
- Marine environment
- Maritime activities
- Mitigating climate change
- Natural capital and ecosystem services
- Noise
- Resource efficiency
- Soil
- The air and climate system
- Tourism
- Transport
- Urban systems
- Waste.

Cross-country comparisons

A set of 9 briefings, which address:

- Agriculture — organic farming
- Air pollution — emissions of selected pollutants
- Biodiversity — protected areas
- Energy — energy consumption and share of renewable energy
- Freshwater quality — nutrients in rivers
- Mitigating climate change — greenhouse gas emissions
- Resource efficiency — material resource efficiency and productivity
- Transport — passenger transport demand and modal split
- Waste — municipal solid waste generation and management.

These comparisons are based on environmental indicators common for most European countries.

Countries and regions

A set of 39 briefings, which summarise reports on the state and outlook of the environment in each of 39 European countries:

- 33 EEA member countries
- 6 cooperating countries in the Western Balkans.

In addition, 3 briefings give an overview of the main environmental challenges in selected regions that extend beyond Europe:

- Arctic region
- Black Sea region
- Mediterranean Sea region.

Setting the scene

Why are global megatrends important for Europe?

Europe is bound to the rest of the world through multiple systems, enabling two-way flows of materials, financial resources, innovations and ideas. As a result, Europe's ecological and societal resilience will be significantly affected in coming decades by a variety of global megatrends — large-scale, high impact and often interdependent social, economic, political, environmental or technological changes. This report analyses 11 megatrends that are considered to be of key importance for Europe's long-term environmental outlook. It builds on the analysis initiated as part of the EEA's report *The European environment — state and outlook 2010* (SOER 2010; EEA, 2010).

Many global trends have significant consequences for Europe. For example, demographic, economic or geopolitical developments elsewhere can influence the availability and price of natural resources and energy in Europe. Increasing environmental pollution in other world regions likewise contributes to direct environmental and human harm in Europe. For instance, although European emissions of ozone precursor gases have declined significantly in recent decades, measured concentrations of ground-level ozone have not fallen at most ground monitoring stations (EEA, 2014a). There is evidence that this is partly due to the long-range transport of precursor gases from other parts of the world (HTAP, 2010).

Conversely, Europe contributes to environmental pressures in other parts of the world. Greenhouse gas emissions in Europe contribute to climate change impacts elsewhere and potentially far into the future. Globalised supply chains mean that European consumption contributes to pressures on ecosystems and communities in other areas of the globe, for example through threats to global freshwater quality and quantity, and the degradation of habitats and landscapes (Tukker et al., 2014).

This report explores how global developments may impact Europe, particularly the European Union (EU), and its environment. A global-to-European perspective is relevant for European environmental policymaking because Europe's systemic environmental challenges and response options are increasingly shaped by global drivers. Similarly to other advanced economies, Europe's relative size and influence on the global economy is expected to decline in coming decades. This changing global setting presents both challenges and opportunities.

The development of some global megatrends and related impacts over coming decades is becoming better understood. However, many uncertainties remain, associated with multiple drivers and change factors that unfold differently across world regions and over time. Global megatrends can also be perceived in contrasting ways by different societal groups and stakeholders. Continued global population growth, for example, can be seen as either a boost or a burden for economic development; urbanisation can be perceived as a source of growing pressures on ecosystems, or as an opportunity for more resource-efficient lifestyles.

These uncertainties notwithstanding, it is clear that 'business as usual' is no longer a viable development path for Europe. Current lifestyles in Europe and other developed regions put excessive pressures on the environment (Figure 0.1). Furthermore, as a growing global middle class increasingly adopts the resource-intensive consumption patterns of advanced economies, the total environmental burden is rapidly moving beyond globally sustainable limits (Rockström et al., 2009). This represents a growing threat to future advances in living standards and increasingly raises questions about the fairness of the wealthy imposing highly disproportionate burdens on the global ecosystem.

These trends underline the need for action to reconfigure systems of production and consumption so that they operate within planetary limits and thereby ensure the well-being of current and future generations. In Europe, as elsewhere, efforts to manage environmental pressures, economic development and human well-being need to overcome the short-termism currently dominating political and economic thinking and embrace long-term, integrated, global perspectives instead.

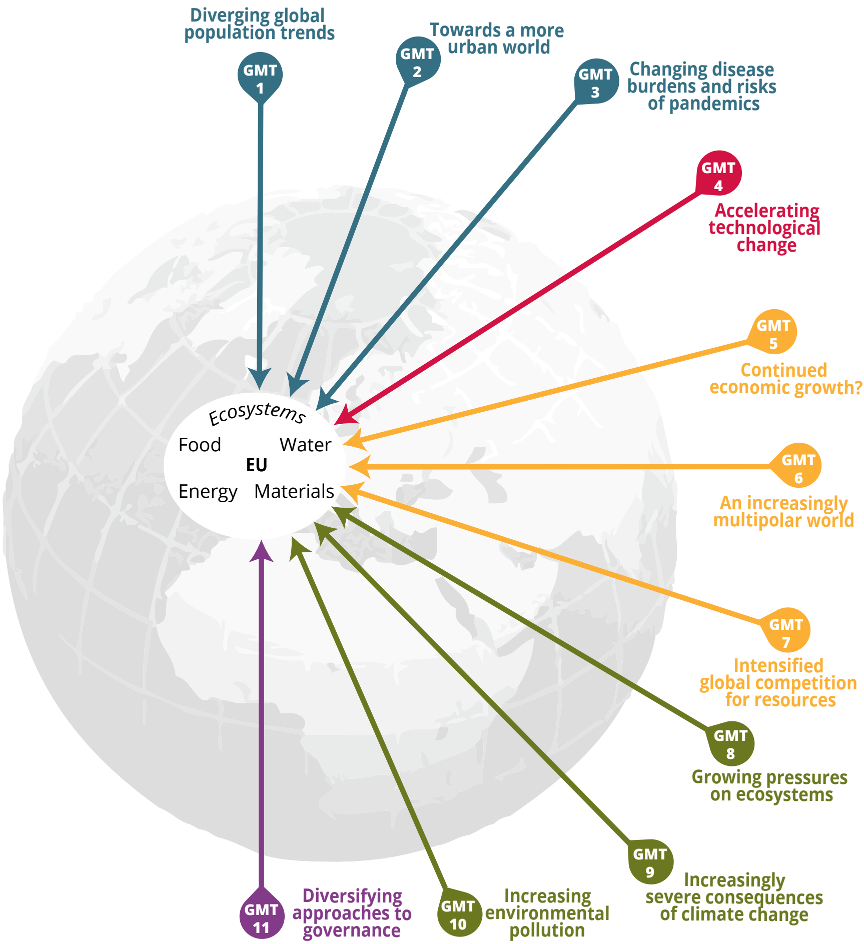
Figure 0.1 **Correlation of Ecological Footprint (2008) and Human Development Index (2010)**

Note: The Human Development Index is calculated using three components: education, life expectancy at birth and wealth. It is expressed as a value between 0 and 1, from less to most developed countries.
The Ecological Footprint measures how much land and water area a population requires to produce the resources it consumes and to absorb its waste. The world biocapacity is the global productive area available on Earth (it decreases as population grows).

Source: Global Footprint Network, 2012; UNDP, 2014a.

The next section aims to illustrate some of the ways that together the 11 global megatrends analysed in subsequent chapters of this report may impact Europe in coming decades, focusing on the ability of Europeans to meet their basic resource needs (Figure 0.2). The analysis is indicative rather than comprehensive, focusing on selected resources and assuming a business-as-usual situation based on current policies. It aims to trigger reflections on the possible implications of global megatrends for Europe.

Figure 0.2 Impacts of global megatrends on European resource systems



Source: EEA.

The final section of this chapter identifies potential policy responses to influence the megatrends or manage their impacts on the European environment.

Implications of global megatrends for Europe's ability to meet its resource needs

The resources that societies rely on to meet their basic needs can be classified into four major categories: food, water, energy and materials (EEA, 2013b). In addition, ecosystems are essential to ensure the availability and quality of these resource categories, as well as providing a range of other ecosystem services that shape human health and well-being. The 11 megatrends differ in their impacts on the various resource categories, both in terms of their magnitude and the directness of their effects.

Food

Meat consumption is expected to increase by more than 70% globally between now and 2050 if current lifestyles and diet patterns remain unchanged (FAO, 2012b). Most of the increased demand is expected to occur outside Europe, and will strongly increase the pressure on global ecosystems through conversion of natural habitats into agricultural land. Conservative estimates suggest that global terrestrial biodiversity will decline by at least another 10% by 2050 (OECD, 2012b), and that soil degradation and water erosion will cause large-scale losses of valuable agricultural land. In addition, global food security is expected to be compromised by increasingly adverse impacts on agricultural yields from climate change and by increasing levels of pollution, the latter particularly in Asia.

Europe relies to a considerable extent on imports to meet domestic demand for food, in particular vegetables, fruit, seafood, coffee, tea and cocoa (Eurostat, 2011). The global developments described above could impact Europe directly through food-price increases or more indirectly through environment- and poverty-induced human immigration. These effects could be aggravated by interactions with other global megatrends. In particular climate change and the increasing global pollution load may adversely and directly impact the amount and quality of food produced on European territory.

Water

Globally, the availability of sufficient good-quality freshwater is increasingly threatened by population growth and increasing consumption, combined with adverse impacts from climate change (Murray et al., 2012). Even if water is used more efficiently, the absolute agricultural intensification needed to meet the world's growing food and feed demand could lead to severe water stress in many world regions in the coming decades (Pfister et al., 2011). Developments projected to occur outside Europe, such as strongly increased drought frequency due to climate change (for example in the Middle East and North Africa) or increasing levels of water pollution (for example in China), might be felt indirectly in Europe through price shifts and related economic impacts, or increased requests to contribute to large-scale international financial assistance.

Climate change and global pollution levels also exert direct pressures on European freshwater quantity and quality. Drought and resulting water scarcity related to climate change are expected to increase considerably in southern Europe, where 80% of national water abstraction is already used for agricultural irrigation (EEA, 2013b). In contrast, western and northern Europe are likely to face increased flood damage (Rojas et al., 2012). Moreover, the transboundary transport of pollutants emitted outside Europe is anticipated to play an increasing role in the future, with potentially adverse impacts for European freshwater quality, such as water acidification (HTAP, 2010).

Energy

As Europe is heavily dependent on fuel imports for its energy supply, its access to energy resources is significantly influenced by global population and economic trends. World energy demand is projected to increase by 30–40% over the coming 20 years (IEA, 2013). Due to the globalised nature of energy resource flows combined with the prominent role of subsidies in the energy sector, changes in economic power blocs, trade agreements, or geopolitical conflicts are likely to have large impacts on Europe.

European energy supply is expected to be increasingly affected by climate change, for example by decreasing the availability of cooling water for nuclear generation due to longer periods with low river-flows and increased river water temperatures. The European energy system also has strong links with pressures on global ecosystems, in particular in relation to bioenergy production. Bioenergy-crop farming to meet renewable energy demands in developed countries, including in Europe, is one of the main drivers of habitat destruction and tropical deforestation, and its associated global water footprint is projected to increase tenfold by 2030 (Gerbens-Leenes et al., 2012). The expansion of bioenergy-crop production can create significant trade-offs and potential competition with increasing global food demand, as well as causing displacement and other social impacts on small-scale farmers in developing countries (German et al., 2011).

Materials

Global demand for materials has increased tenfold since 1900 (Krausmann et al., 2009), and is projected to double again by 2030 (SERI, 2013). Countries in developing regions, notably China and India, account for a rising proportion of global trade flows and material resource use. Growing global competition for resources represents a major concern for Europe since it is structurally dependent on imports for many key resources — for example 58% of metal ores consumed in the EU-28 in 2013 were imported.

There are particular concerns about access to certain 'critical raw materials', which have limited deposits in Europe or are absent altogether. World production of these materials is often monopolistic in character, with a single country, frequently China, in control of the global market. This raises concerns about future resource access and prices, in particular because global demand for materials such as niobium, gallium and other rare Earth metals is projected to grow by more than 8% annually in the coming five to ten years (EC, 2014d). Many emerging and prominent green technologies, including photovoltaics, wind turbines, hybrid and electric cars, are currently dependent on these critical raw materials. Access to certain materials could therefore have an important impact on the long-term transition of the European energy sector away from fossil fuel dependency (EC, 2014d).

Ecosystems

The interplay of environmental pressures from intensifying global use of food, water, energy and materials is apparent at the landscape scale. Models consistently project global ecosystem depletion and biodiversity loss to continue or accelerate under all existing policy scenarios (Leadley et al., 2010). Many people in developing countries rely heavily on their local environment to meet their basic needs (TEEB, 2010), meaning that continued ecosystem destruction could drive significantly increased migration. Ultimately, the destruction of ecosystems in other parts of the world is likely to increase the environmental pressure on European ecosystems.

More direct pressures on European ecosystem resilience derive from urbanisation, in particular from landscape fragmentation due to urban sprawl and expanding transport infrastructure. Between 1990 and 2006, industrial areas and infrastructure in Europe expanded by 45%, residential areas grew by 23%, but population increased by only 6% (EEA, 2013b). Moreover, European terrestrial ecosystems are expected to be increasingly affected by drought, wildfires, floods, glacier melt, or species extinctions due to climatic changes expected in the decades ahead. Marine ecosystems are projected to suffer from the combined effects from temperature increases, ocean acidification and sea level rise. Although significant reductions in European pollution levels have been achieved, severe problems persist, such as the eutrophication of aquatic ecosystems due to high nutrient concentrations originating from sources such as agriculture and urban waste water systems.

Responding to global megatrends — challenges and opportunities for Europe

As the examples in the previous section illustrate, the boundaries between developments in Europe and other parts of the world are growing more blurred. Europeans are increasingly affected by changes in distant regions — some very sudden, others unfolding over decades. Policy planning and strategic decision-making must, therefore, reflect the long-term and global contexts. That means finding ways to produce sufficient food, water, materials and energy to meet the needs of a growing global population, while maintaining ecosystem resilience and services.

Acknowledging the long-term and global context in strategic planning

Several recent global and European initiatives have embraced the need for long-term, global, and strategic risk assessment. For example, the European Strategy and Policy Analysis System (ESPAS) has assessed the long-term political and economic environment facing Europe over the next 20 years, and Europe's policy response options (ESPAS, 2012). It emphasised that Europe and the world are experiencing a period of accelerated change, in particular with respect to power, demographics, climate, urbanisation and technology.

Similarly, the World Economic Forum (WEF) has identified ten global risks of the highest concern for business. Four of these — concerning water, food, climate change responses and extreme weather events — relate directly to the environment (WEF, 2014). Environmental themes likewise appear prominently in the 17 proposed Sustainable Development Goals (UN, 2014a) that have been drafted pursuant to the UN's Rio+20 outcome.

Increasingly, European strategic policy processes are also incorporating long-term and global perspectives. For example, to guide short- and medium-term actions, the EU's 7th Environment Action Programme (EU, 2013) sets out a 2050 vision that Europe should 'live well within the planet's ecological limits'. It acknowledges that 'global systemic trends and challenges, related to population dynamics, urbanisation, disease and pandemics, accelerating technological change and unsustainable economic growth add to the complexity of tackling environmental challenges and achieving long-term sustainable development'. It further recognises that 'many environmental challenges are global and can only be fully addressed through a comprehensive global approach'.

Two approaches to addressing global megatrends

Global megatrends are, by their nature, a manifestation of a vast number of processes and changes across the world. Faced with shifts of this character, Europeans have two main clusters of response options. First, they can seek to **shape global change** in ways that mitigate and manage risks, and create opportunities. This could be achieved, for example, through unilateral and multilateral efforts to mitigate environmental pressures or facilitate trade, or through using foreign aid mechanisms to invest in education and poverty alleviation.

Second, they can find ways to **adapt to global trends**. This could take the form of seeking to anticipate and avoid harm by increasing the resilience of social, environmental and economic systems. It could involve restoring damaged ecosystems or correcting social impacts that have already occurred. Or it could involve exploiting opportunities that arise as a result of the changes, such as the commercial opportunities associated with innovation, expanding global markets and prosperity.

European policy measures

These two clusters of responses are already emerging to some degree in recent European environmental policy initiatives, notably in efforts to increase resource efficiency and create a low-carbon society. The EU's *Roadmap to a Resource Efficient Europe* (EC, 2011b) and its *Roadmap for moving to a competitive low-carbon economy* (EC, 2011a) include visions and targets stretching as far ahead as 2050, emphasising the need for long-term transformation of Europe's systems of production and consumption.

In accordance with these long-term goals, the EU's *Raw Materials Initiative* (EC, 2008, 2014b) and the *European Innovation Partnership on Raw Materials* (EC, 2012a) under the EU's *Innovation Union Flagship Initiative* (EC, 2010a) aim to reduce the EU's import dependency by boosting resource efficiency, substitution and recycling. Efficiency improvements can augment Europe's economic resilience to global trends by lessening its vulnerability to uncertain supplies and volatile prices. At the same time, they can help mitigate Europe's contribution to escalating global resource demand; boost competitiveness by reducing production costs; and drive innovation in green sectors which are likely to grow in importance globally in coming decades.

Similarly, European climate and energy policy includes adaptation measures, such as the EU *Strategy on Adaptation to Climate Change* (EC, 2013a), alongside efforts to enhance energy efficiency and mitigate carbon emissions both within Europe and across the world. The EU is a vigorous proponent of a robust global regime to reduce greenhouse gas emissions and has played a leading role through its emissions reductions pursuant to the Kyoto Protocol and its own unilateral targets for 2020 and 2030 (EC, 2009b, 2014a). Alongside these measures, European energy technology policy pursues a Strategic *Energy Technology Plan* (SET-Plan) to accelerate the development of low carbon technology (EC, 2010b).

Policies also have an important role to play in financing the research and innovation needed to reconfigure European systems of production and consumption. With nearly EUR 80 billion of funding available over seven years — 2014–2020, the EU's *Framework Programme for Research and Innovation* (Horizon 2020) aims to foster scientific excellence and industrial leadership, and address societal challenges such as food security, climate action and resource efficiency (EC, 2015a).

Overcoming the gaps in global governance

While Europe has made some progress in enhancing resource efficiency and reducing environmental pressures, it is clear that individual governments or regional blocs face significant challenges in influencing global trends. As Held (2006) notes, 'the collective issues we must grapple with are of growing extensity and intensity and, yet, the means for addressing these are weak and incomplete'.

This observation certainly applies to management of the global environmental commons, for example in efforts to reduce greenhouse gas emissions or preserve public goods such as biodiversity and carbon sinks such as forests. But the same problem is also apparent in other areas requiring collective and collaborative global action, such as in meeting basic human needs by, for example, preventing poverty, conflict and global infectious diseases, and in enforcing global rules, for example regarding toxic waste disposal, intellectual property rights, regulation of finance and taxation of multinational companies. In essence, the globalisation of economic, social, technical and environmental flows has not been matched by the emergence of effective global governance mechanisms.

Strengthening global governance will partly require that governments reinforce rule-based forms of governance based on international institutions, laws and enforcement mechanisms. For Europe, obvious priorities in 2015 include the adoption of a robust global climate change agreement, and the Sustainable Development Goals as part of a post-2015 development agenda. There is also scope for the EU to extend the reach of its own regulations beyond Europe by taking advantage of commercial incentives for harmonisation of production standards across the world. This process is illustrated by the continuing adoption of EU 'Euro' emissions standards for road vehicles in Asian countries (EEA, 2014b) and the emulation of Europe's REACH legislation on chemicals in countries such as China (EC, 2006).

While regulatory and market-based tools have a clear role to play in addressing the challenges that have accompanied globalisation, decision-making processes at the global scale are frequently slow and complex, and enforcement mechanisms are often lacking. These limitations, as well as the opportunities presented by recent technological and social innovation, are driving the emergence of more participatory network governance approaches, based on more informal institutions and instruments. For example, non-governmental organisations and businesses play a growing role in developing, promoting and monitoring standards that influence the environmental and socio-economic impacts of production and consumption.

Crucially, responding to the weaknesses of governance across the world requires action at all scales — from intergovernmental processes to individual citizens. Cities and other subnational levels of government are increasingly engaged in cross-border networking and governance, as illustrated by the Covenant of Mayors (CM, 2014). Consumers and shareholders can also influence production practices across the world through their purchasing choices and investment decisions.

Enhancing the knowledge base to support transitions

Improving Europe's responses to global megatrends also depends on credible information on possible future developments and choices in the face of global risks and uncertainties. Better information is needed to mainstream long-term and global perspectives into policy. Increased use of foresight methods, such as horizon scanning, scenario development and visioning could strengthen long-term decision-making by bringing together different perspectives and disciplines, and developing systemic understanding. Impact assessments of the European Commission (EC, 2015b) and EU Member States, for example, could be enhanced if they were systematically required to consider the long-term global context.

Foresight methods could also enhance the usefulness of model-based quantitative projections and provide a platform for collaboration across government departments. Participatory approaches to scenario assessments could help increase the legitimacy and robustness of alternative options and pathways. Including forward-looking assessments and indicators in regular reporting on the state of the environment could likewise improve understanding of future trends and uncertainties.

Europe has many opportunities to improve the knowledge base for long-term decision-making and planning. In addition, a key condition for making better decisions under conditions of uncertainty is that robust information is complemented by appropriate political support and institutional capacity.

In times of economic and financial crisis, Europe should not lose sight of its long-term vision of 'living well within the planet's limits'. Investments aimed at economic recovery should be environmentally sustainable and should reflect the changing global context. As recently acknowledged by a Task Force on European investment potential, investing in areas such as resource efficiency, eco-innovation, the bio-economy and management of resource- and climate-related risks is critical for Europe's long-term growth prospects, contributing to competitiveness, prosperity and well-being (EC, 2014e).

Diverging global population trends

The world population may rise beyond 9.6 billion by 2050, despite the rate of growth slowing. Most of the increase will occur in developing-world urban areas. Growing and younger populations in the developing world, the global growth of an affluent middle class, and ageing populations in developed countries will affect resource use and the environment.

Such unequal developments are likely to increase migration. Europe, with an ageing population, could face pressure for and from immigration. Through its environmental policies and international dialogue, Europe should persist with efforts to decouple resource use from economic development.

Drivers

Fertility and mortality

The interaction of fertility and mortality rates ([1]) influences population size. By 2005–2010, the global fertility rate had declined to 2.5 and is expected to fall to 1.8 by 2050, other than in Africa where it is unlikely to fall below 3.0 before 2050. Mortality, including childhood mortality, rates have also decreased resulting in global average life expectancy rising to 69 in 2005–2010, with significant regional variations, and is expected to reach 75 by 2045–2050 (UN, 2013b).

Economic development

Research suggests strong links between fertility levels and economic development. As per person incomes rise, fertility tends to fall, and eventually reach, and then maintain, replacement levels. Economic growth also impacts migration patterns, as development discrepancies seem to be a driver of migration (Biois, 2013b; The Economist, 2009a).

([1]) The fertility rate is the number of children born to a woman during her lifetime. The mortality rate is the number of deaths in a population or a segment of a population.

Education

Education, especially of girls and women, is associated with lower fertility, better health and reduced levels of morbidity and disability (Crespo Cuaresma et al., 2014). Lutz and Samir (2011) show how different levels of education could result in a difference in the global population of more than 1 billion by 2050 depending on whether the world follows a high- or low-education scenario.

Access to services

Access to nutrition, clean water, sanitation, and health services all reduce mortality, especially childhood mortality, and drive longevity — with health programmes targeting women's reproductive health playing a key role. Universal health coverage, however, remains a distant goal, while estimates suggest that more than 222 million women have an unmet need for modern contraception (UNFPA, 2012a; WHO, 2014b).

Trends

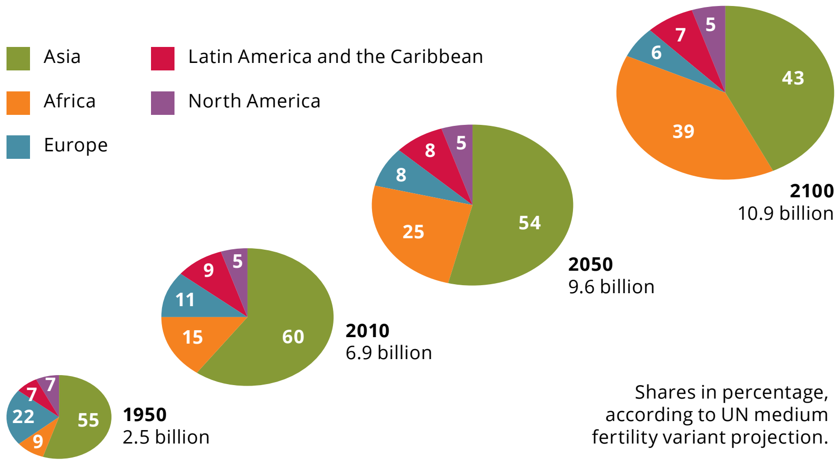
Global growth

The world population has more than doubled since the 1960s, exceeding 7 billion in 2013 (UN, 2013b). It will continue to grow, but at a slower rate, reaching 8.3–10.9 billion by 2050, with a medium variant ([2]) of 9.6 billion (UN, 2013b), depending on the policies pursued today (UNFPA, 2011).

Virtually all growth is projected to occur in developing countries, and particularly their cities, with population in these countries rising from 5.9 billion in 2013 to 8.2 billion in 2050, changing the global balance (Figure 1.1) — population in developed regions is likely to stagnate or grow slightly, mostly due to immigration (Figure 1.1). Some regions, however, where the population is still growing are expected to move towards decline — it has already begun in the Caribbean, Japan, Russia and South America (UN, 2013b).

([2]) The medium variant is defined by certain assumptions about future fertility trends in developed and developing countries. It is not a mean growth estimate.

Figure 1.1 World population in 1950, 2010, 2050 and 2100



Note: The population of Oceania (not shown), which represents less than 1% of the world population, rises five-fold over the period.

Source: UN, 2013b.

Changing age structures

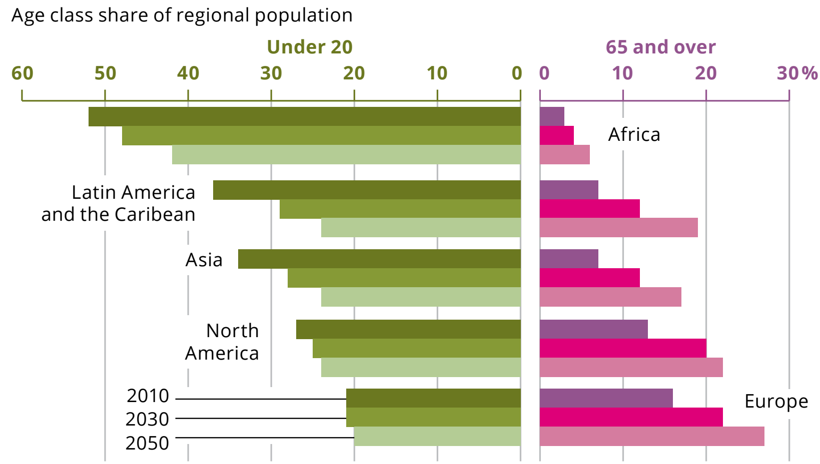
Declining fertility levels, coupled with gains in life expectancy, are increasing the world's median age, which is expected to increase from 28 to 36 between 2010 and 2050, and raise the percentage of over 65s from 8–16% of the global population by 2050 (UN, 2013b). Contrary to the aging population of developed regions, some developing-world countries are or will soon experience substantial youth bulges (Figures 1.2 and 1.3). Providing educational and employment opportunities for these young people will be challenging, but critical if political and social stability is to be ensured (NIC, 2008).

Shifting migration patterns

Since the 1960s, there has been a trend of migration from less developed to more developed regions. In 2010, however, the growth rate of the international migrant stock in developing countries surpassed that of developed countries for the first time. Several countries in developing regions (e.g. Kuwait, South Africa and Thailand) have been attracting significant numbers of migrants, including refugees from neighbouring countries (UN, 2011). China, India and South America could attract more migrants as growth in their working-age population slows and wages rise (NIC, 2008).

Although economic and social motives are still key drivers for migration, environmental degradation and climate-change impacts are becoming increasingly important due to increased exposure to natural hazards and the corresponding threats to livelihoods (Foresight, 2011; ICMPD, 2011). In some instances, however, climate change impacts and environmental degradation can actually deter migration if communities lack the resources

Figure 1.2 **Share of population under age 20 and over age 65 by regions in 2010, 2030 and 2050**



Source: UN, 2013b.

to meet the costs of relocating (Foresight, 2011). Due to the high degree of complexity and uncertainty in calculations, projections for climate change-induced migration by 2050 vary from 25 million people to one billion people (IOM, 2009).

Implications

Environmental pressure

UNEP assesses population growth and patterns of production and consumption as the main drivers of environmental and land-use change. Population growth and related economic development boost humanity's use of and competition for non-renewable resources while escalating the consumption of biotic resources, the production of harmful emissions and waste, and the disruption or destruction of natural habitats (GMTs 8 and 10). Environmental damage may become particularly significant in sub-Saharan Africa and parts of south-east Asia, where high population growth rates coincide with a direct dependency on natural capital — forests, fisheries, freshwater etc. (IOM, 2009; OECD, 2012a).

In the longer term, changing patterns of consumption, in part driven by the development of a growing, increasingly affluent middle class in developing regions (GMTs 2 and 5) are likely to boost unsustainable practices that erode essential and irreplaceable natural resources and increase pollution, processes which will undermine the very basis for economic growth and social progress (UNFPA, 2012b).

Economic impacts of expanding work-forces

Population trends directly influence economic activity, shaping the size and age structure of working populations (Figure 1.3). In many countries, strong growth in the working-age population, alongside improvements in health and education, and investment in infrastructure and technology, have contributed to rapid economic growth (NIC, 2008; WEF, 2012). The share of the population with secondary and tertiary education is projected to increase everywhere by 2050, particularly in Asia and Africa, potentially boosting further economic growth (Figure 1.3). China, for example, is expected to have more educated people of working age than Europe and North America combined by 2030 (OECD and UNDESA, 2013; Samir et al., 2010). This trend is already apparent. While advanced economies dominated growth during the 20th century, emerging economies are rapidly gaining prominence, partly by providing a production centre for developed economies. Brazil, Russia, India, Indonesia, China and South Africa (BRIICS) accounted for 21% of global output in 2000, 32% in 2010 and, according to projections, their economic production will exceed the GDP of OECD members by around 2030, and will account for 56% of global GDP by 2050 (OECD, 2014a).

Social cohesion

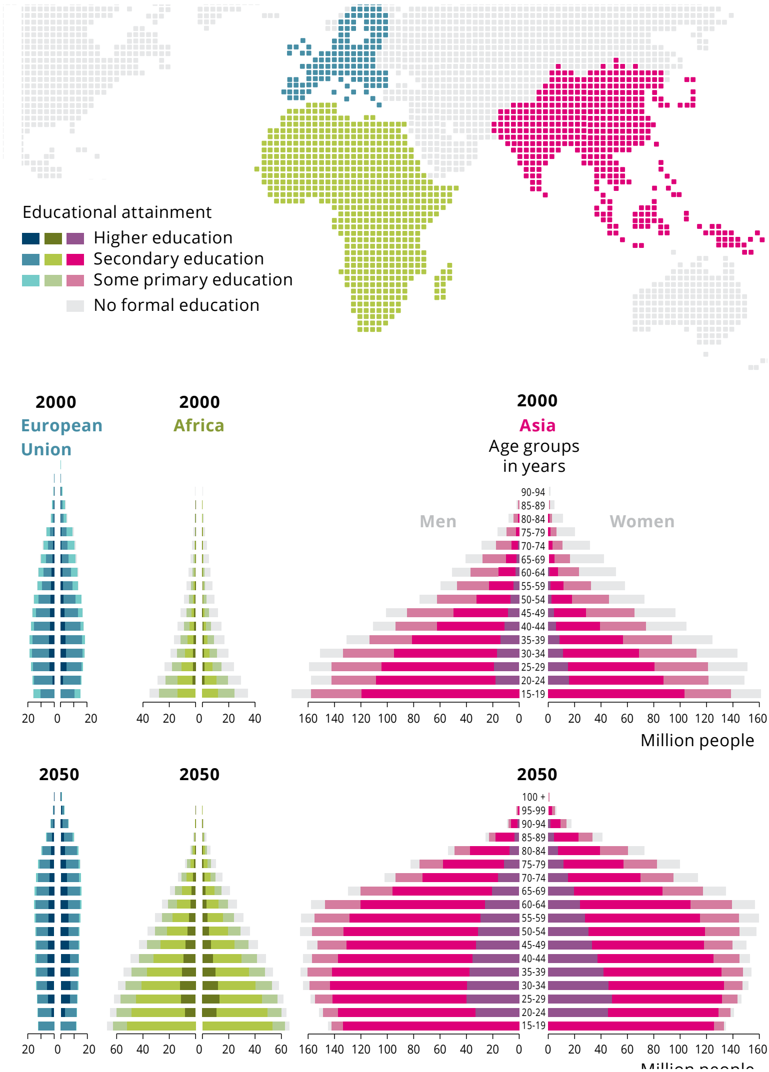
The world reached a peak in its share of 15–24 year-olds around 1985, but in the least-developed countries it only occurred in 2005 and the proportion of young people will remain high in the coming decades with the largest youth bulges likely in sub-Saharan Africa and the Middle East (Figure 1.2). Failing to create employment opportunities for young people is both a waste of human resources and a source of potential conflict (NIC, 2008). Policies supporting an increase in choices and opportunities, including the provision of contraceptive services, can support desirable population trends and mitigate negative effects in the future (UNFPA, 2012a). In developed countries, social cohesion is more likely to be threatened by an aging population and population decline (Figures 1.1, 1.2 and 1.3). These may alleviate some of the demands on ecosystems, and the right policies could ensure that the growing number of older but active people provide an economic dividend (Biois, 2013b). Nevertheless, an aging population can threaten social security, taxation, and public health systems. Policymakers will have to make difficult trade-offs, some of which can be mitigated by early action on structural reforms (OECD, 2014a).

Immigration may alleviate some of these pressures by putting more people of working-age, often with higher education, into employment. It is estimated, for example, that 30% of migrants in the OECD have tertiary education (OECD et al., 2013). In developing regions, however, the emigration of highly skilled people is a major concern; for example one in nine tertiary-educated people born in Africa now resides in OECD countries (OECD et al., 2013). Migration of young workers can, nonetheless, deliver economic benefits to their native countries; the World Bank estimates that remittance flows to developing countries in 2013 were nearly three times the size of official development assistance and will increase (WB, 2013).

Implications for Europe

Europe's population is aging rapidly (Figure 1.2), and is likely to stagnate — significant increases in some Member States balancing declines in others. This may ease, though not curb, environmental pressures, but much depends on environmental policies to address such issues as urban sprawl and production and consumption habits. One environmental concern is the decline of household size, which has accelerated since 1900 (Bradbury et al., 2014). Furthermore, likely demographic trends will create other challenges — an expanded workforce during recent decades has underpinned improvements in living standards and the development of the welfare state. Sustaining these may be difficult in the light of population dynamics (Biois, 2013b). EU Member States may be able to pre-empt some challenges, for example through integrated urban management or effective support structures for older populations. Nonetheless, keeping the global nature of environmental issues in mind, Europe should persist, both through its own policies and engagement in international dialogue on environmental issues, with efforts to decouple natural resource use and the production of pollution from economic development in the move towards a green economy (Biois, 2013b).

Figure 1.3 Population pyramids for Europe, Africa and Asia for 2000 and 2050 by age, sex and educational attainment



Note: Projections for 2050 according to the Global Education Trend (GET) scenario. Back and forward projection methods are used to reconstruct populations by age, sex, and level of educational attainment. The back projections cover 1970–2000. The forward projections are for 2005–2050.

Source: Samir et al., 2010.

Towards a more urban world

> Urban areas in developing countries will absorb most of the global population increase, with 67% of people living in cities by 2050. Most of the growth is expected to be in megacities, particularly slums.
>
> Compact cities are the most efficient and environmentally sustainable way to secure the welfare of a growing population. Smart planning provides for the efficient re-use and mixed-use of urban space. Urban growth is driving land-use change in Europe, with peri-urban areas developing at four times the rate of towns and cities. Integrated urban management could increase the environmental resilience of Europe's cities, particularly in the east and south.

Drivers

Growing global urbanisation is driven by developing-world industrialisation, agricultural mechanisation, and environmental change, but above all by growth of the global population. Today there are 7 billion people, but 8.3–10.9 billion are expected by 2050, with a medium variant ([3]) of 9.6 billion (GMT 1).

Developed countries, searching for lower-cost production, increasingly source materials, products, components and services from the developing world. Just as trade and industry grew Europe's cities, developing-world suppliers are driving the growth of theirs. One industry attracts others, and workers, too, need products and services — building a virtuous cycle of development (Bettencourt and West, 2010) — Massachusetts Institute of Technology researchers suggest that as a city's population doubles, economic productivity increases by 130% (MIT, 2013). This is now occurring in Africa, Asia and Latin America.

As happened in the developed world, advanced, industrial agricultural techniques, requiring fewer but highly skilled workers, are now being

([3]) The medium variant of population projections is defined by certain assumptions about future fertility trends in developed and developing countries. It is not a mean growth estimate.

applied in the developing world, reducing the size of the workforce, depressing wages and stimulating large numbers of rural people to seek livelihoods in towns and cities (Andzio-Bika and Wei, 2005).

Environmental degradation, often linked to global, regional and national patterns of production and consumption (GMT 10), increasingly fosters internal and international urban immigration from rural areas. This can be particularly severe in rural areas and societies with a direct dependency on local natural resources. Sub-Saharan Africa and parts of south-east Asia, where high population growth coincides with a direct dependency on forests, fisheries, freshwater, etc. may be particularly hard hit (IPCC, 2007).

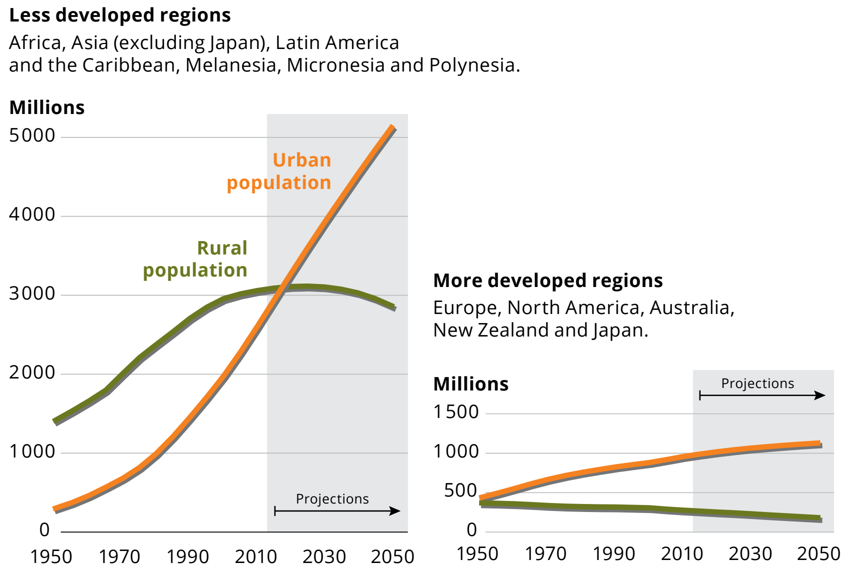
Trends

Although urban areas ([4]) cover just 2.8% of the global land area, they are home to more than half the world's population — around 3.5 billion people (BESS, 2014). In 1950, only around 700 million people lived in cities, while by 2050 about two-thirds of the world's expected population, probably 6.2 billion people, are projected to be urban (Figure 2.1). Between now and 2050, using the UN's median variant, the world's population is expected to rise by about 2.7 billion people, of whom 2.3 billion are projected to live in developing world urban areas, mostly Africa and Asia, swelling the population of developing world cities to 8.2 billion (GMT 1) (UN, 2012). Urbanisation can blur the divides between urban and rural areas, creating ever-larger and ever-more important peri-urban areas ([5]), with their own range of specific characteristics, problems and opportunities (Piorr et al., 2011).

([4]) There is no universal definition for the term 'urban'. The projections are based on definitions established by the countries themselves. Population size and density are among the most frequently used criteria. It should be noted, however, that the lower population size limit ranges from 200 to 50 000 inhabitants. In Europe, it is defined as continuous built-up area with a population of more than 20 000 (Piorr et al., 2011). For more information, please see UN (2014). Similarly, there is also no common approach on when an urban area becomes a city. For convenience, these terms are used interchangeably in this report.

([5]) Peri-urban areas are a kind of multifunctional territory between urban settlements and their rural hinterland. Peri-urban areas are discontinuous built development, containing settlements of less than 20 000 people, with an average density of at least 0.4 people per hectare (Piorr et al., 2011).

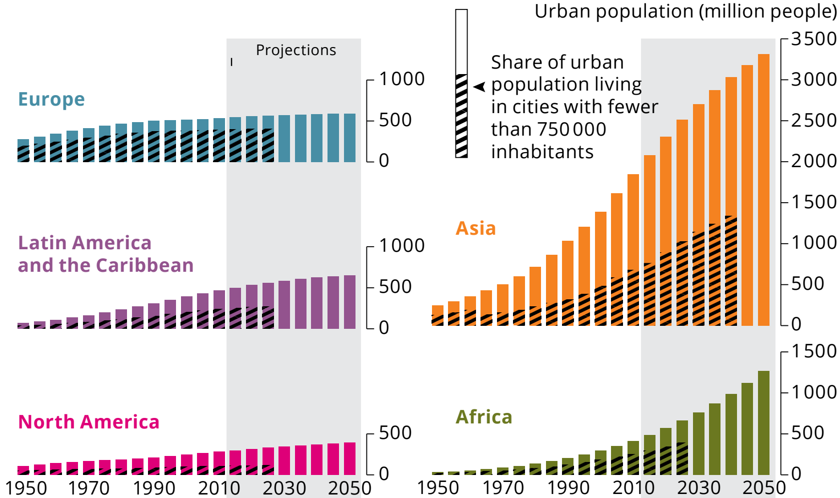
Figure 2.1 Urban and rural population in developed and less developed world regions, 1950–2050



Source: UN, 2012.

Currently, 80% of North America's, South America and the Caribbean's population is urban; 70% in Europe, 40% in Africa and 48% in Asia (JPI Urban Europe, 2011; UN, 2014c). However, the latter two regions are urbanising rapidly (Figure 2.2). Africa presently has 400 million urban inhabitants, 11% of the world's urban population, but by 2050 this is expected to rise to 2 billion, 32%, with most of the growth happening in slums (JPI Urban Europe, 2011). Asia presently has 1.8 billion people living in cities, 51% of the world's urban population, estimated to rise to 3.3 billion, 53%, by 2050, mostly in the large cities of China and India (UN, 2012, 2014c). But even allowing for the rapid pace of developing-world urbanisation, developed countries will become more urbanised by 2050, with rates of 86% of their population urban, compared to 64% in the developing world (Figure 2.2) (JPI Urban Europe, 2011).

Figure 2.2 Urban trends by world regions, 1950–2050



Source: UN, 2012.

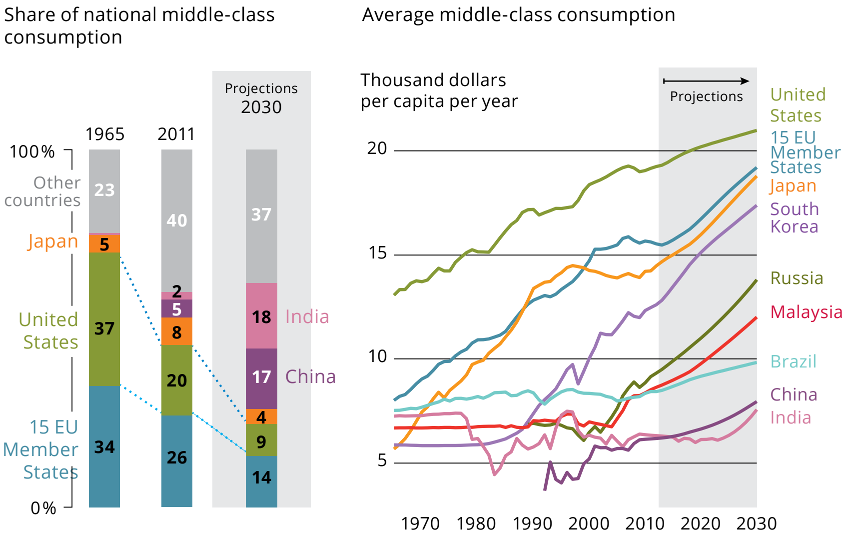
Tokyo and New York were the only megacities, with more than 10 million inhabitants, in 1970; by 2014 there were 28, most of which were located in the global south; and, by 2030 there could be 41 globally (UN, 2014c). Nonetheless, small and medium sized cities have always been the engine of urbanisation, and although the population of megacities is projected to double by 2025, the largest number of urban dwellers will live in cities of fewer than 500 000 people. Today, 12% of the world urban population lives in megacities while about half live in these smaller cities (UN, 2014c).

Urban density varies from 135 people per hectare in some developing countries, through 70 in most of developed ones to 28 in such land-rich countries as Australia, Canada and the US. In the next 30 years, a doubling of urban populations in developing countries is likely to triple the extent of built-up areas (Angel et al., 2010), while in developed countries, population increase, combined with a demand for more single-person hou§ses, may result in competition for urban green infrastructure (Natural England, 2014).

Urban areas currently generate around 80% of world gross domestic product, with much of this held by the middle class ([6]), a group likely to grow by more than 170% to 4.9 billion by 2030, with Asia accounting for 85% of the growth (Figure 2.3). These citizens have the resources to invest in human and physical capital, providing access to a wide range of goods and services, potentially alleviating insecurity associated with poverty (GMT 3).

In the next 30 years, the doubling of urban populations in developing countries is likely to triple the extent of built-up areas (Piorr et al., 2011). This relative spatial inefficiency is linked to the fact that most future urbanisation is likely to be informal settlements and slums often with inadequate housing, safe drinking water, sanitation or waste disposal.

Figure 2.3 Middle class consumption, 1965–2030



Note: The 15 chosen EU Member States are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom. No Chinese data for 1965.

Source: Kaufmann et al., 2012.

([6]) Kharas (2010) defines the middle class as individuals with total daily household consumption expenditure of between USD 10 and USD 100 in 2005 PPP dollars.

Slums have always been a part of rapid urbanisation, but their current scale is unprecedented — almost 1 billion people live in them; in some African countries more than 90% of urban residents (UN-Habitat, 2013b). If not addressed, the UN estimates that the number of slum dwellers will rise to 3 billion by 2050 (UN-Habitat, 2013a).

Implications

Highly urbanised countries tend to have high levels of human development (UNDP, 2014b), but 60–80% of all resource consumption and energy use, while around half the world's anthropogenic carbon dioxide emissions and environmental/ecosystem degradation can be attributed to cities (UN, 2014c; Global Footprint Network, 2012; UNEP, 2011a; Satterthwaite, 2008). Indeed, China's urban areas alone are projected to consume 20% of the world's energy by 2030 (JPI Urban Europe, 2011).

If well managed, however, resource efficient cities can combine productivity increases and innovation with reduced environmental impacts as major cities tend to generate higher economic output at far lower per person greenhouse gas emissions (Dodman, 2009; UNEP, 2011a) and lower per person consumption of resources. Indeed (UNEP, 2011a) suggests that dense, mixed-use urban settlements can be more resource-efficient than any other with similar levels of economic output. How this potential is used depends on urban planning, as sprawl hinders cities in fulfilling their environmental and resource efficiency potential.

Poorly planned, dense urban settlements, however, bring congestion, overcrowding, pressure on infrastructure and the environment, and higher housing costs (Turok and McGranahan, 2013). The concentration of people and businesses can also significantly undermine health, making it easier for disease to spread (GMTs 3 and 10).

The Food and Agriculture Organization (FAO) argues that population growth, increasing urbanisation, which raises dependency on food purchases, and changing diets are among the factors impacting global food demand, driving countries to seek resources elsewhere (FAO, 2012a). Increased urbanisation and changing consumption patterns are also having a significant impact on the quantity and quality of water resources (EEA, 2009).

Compact, densely populated cities are the most efficient and sustainable model for housing a rapidly growing population and the integrated management of urban activities and natural capital, green infrastructure and biodiversity facilitates future urban planning. The provision and maintenance of green spaces is key, as these provide regulating services, tackling air pollution and reducing flooding for example, encourage biodiversity and, if carefully planned, act as wildlife corridors as well providing cultural and recreational opportunities for people (BESS, 2014; Natural England, 2014).

City governance affects urbanisation. The most successful manages rapid growth at different spatial levels: adequate service provision, urban sprawl, spatial disparities, congestion, pollution, climate change, social issues and distressed areas. Examples of good governance show the success of cities that go beyond the traditional issues of infrastructure management to include such broader elements as the knowledge and skills of workers, and the social capital needed to encourage innovation (GMT 4) (EEA, 2009; OECD, 2012c).

Europe

The interconnectedness of natural systems makes it inevitable that environmental impacts arising elsewhere in the world will affect Europe and its cities, especially air pollution and the rise in greenhouse gas emissions. Indeed, research suggests their increase in developing countries could offset Europe's efforts to mitigate climate change. Moreover, because Europe is relatively resource poor, it is increasingly dependent on imports of fossil fuel, minerals and food, and vulnerable to competition for them (GMTs 7 and 8). While the cities of northern Europe are likely to be relatively resilient to this, those in east and south are less so (JPI Urban Europe, 2011).

As urban development is Europe's fastest-growing category of land-use change, with peri-urban areas growing four times faster than urban areas (Piorr et al., 2011), these issues suggest that Europe should embrace the integrated management of urban activities and natural capital, green infrastructure and biodiversity, as well as technological change, to sustain their competitiveness, foster agglomeration economies and increase resource efficiency.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Changing disease burdens and risks of pandemics

The global burden from non-communicable disease now outweighs that from communicable disease. This has been influenced by increased ageing, and by rapidly changing economic and social conditions. Nonetheless, the threat of global pandemics continues, partly driven by increasing mobility. Around a quarter of the burden of disease and deaths are attributable to environmental causes. The effects of climate change are likely to exacerbate this.

Europe has achieved major improvements in public health. However, an ageing population and the impacts of climate change may necessitate additional public health interventions and adjusted environmental policies.

Drivers

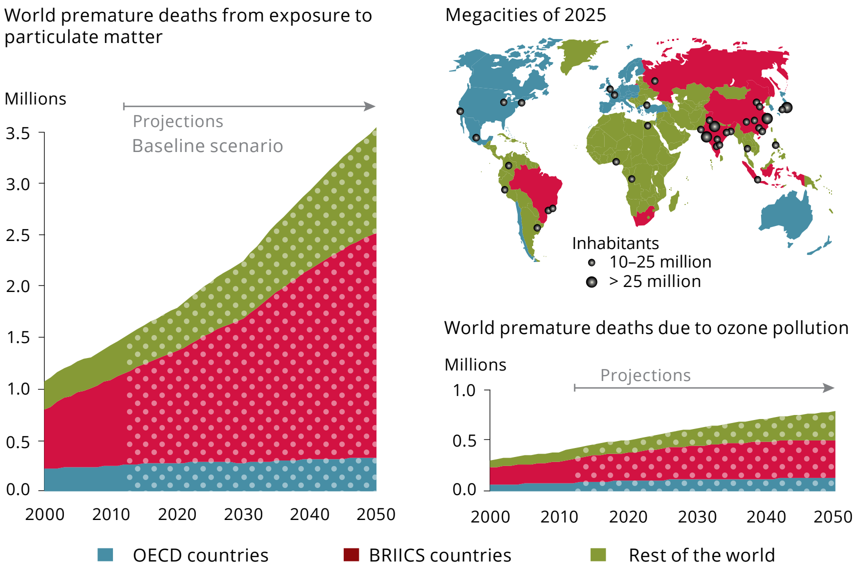
Environmental degradation, climate change, and increased urbanisation, mobility and migration all influence public health (IPCC, 2007, 2014a), for example by raising the risk of the global transfer of infectious disease and exposing people to environmental hazards (GMTs 1, 2, 8 and 10) (EEA/JRC, 2013; Kuipers and Zamparutti, 2014). Elderly and poor people are particularly vulnerable.

Environmental health risks include particulate matter; ozone; indoor air pollution; unsafe water and sanitation; contamination from waste, including from research activities; exposure to chemicals, lead, mercury and other heavy metals (EEA/JRC, 2013; WHO, 2013d); and noise. Overall, 24% of the global burden of disease and 23% of premature deaths are attributable to environmental causes (Lim et al., 2013).

Urban air pollution, especially ambient particulate matter and ozone, are set to become the main environmental cause of mortality worldwide by 2050 (OECD, 2012b; UN, 2014b). The Organisation for Economic Co-operation and Development (OECD) forecasts that the number of premature deaths from exposure to particulate matter in urban areas could more than double to 3.6 billion in 2050, most in China and India. Premature deaths from indoor air pollution, however, are likely to fall in coming years (Lim et al., 2013).

Ozone has a marked effect on human health (Figure 3.1) and is the most damaging air pollutant to vegetation, including crops.

Figure 3.1 World premature deaths due to urban pollution from particulate matter and ground-level ozone, 2000–2050



Note: BRIICS countries are: Brazil, Russia, India, Indonesia, China, South Africa.

Source: OECD, 2012b.

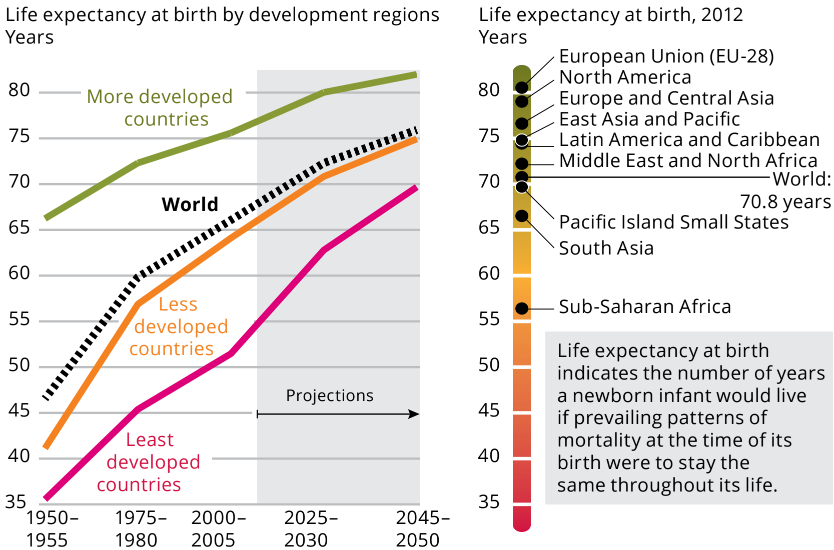
Although economic growth and improved social conditions have reduced poverty, improved nutrition and widened access to safe drinking water, basic sanitation and education, they have encouraged unhealthy lifestyles in the developed world and increasingly among the developing world's rapidly growing middle class. As a result, non-communicable disease (NCD) and medical conditions, including cardiovascular disease, cancers, diabetes, mental disorders and obesity, now outweigh communicable ones ([7]).

([7]) Communicable diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi; the diseases can be spread, directly or indirectly, from one person to another. Zoonotic diseases are infectious diseases of animals that can cause disease when transmitted to humans (WHO, 2014e).

Global average life expectancy reached 71 in 2012 (Figure 3.2) and is expected to rise to 75 by 2045–2050 (GMT 1) (UN, 2013b). Older people, however, are more vulnerable to environmental hazards, spend more years living with injury and illness (Di Cesare et al., 2013) and are susceptible to conditions of ageing, notably dementia.

Economic inequality, poverty and food insecurity continue to affect health outcomes and shorten lives within and across countries. Today 1.2 billion people still live in extreme poverty while in 2011–2013, 842 million people did not get enough food to live active lives (UN, 2014b; FAO, 2013b).

Figure 3.2 Life expectancy at birth by world regions, 1950–2050



Source: UN, 2002 (left); WB, 2014 (right) .

Rapid technological development creates both benefits and risks. Health services have and will benefit from bio-, nano- and information technologies (GMT 4), but their novelty means that the effects of their application on human and ecosystem health are little understood. Their wastes and emissions are of particular concern — for example, while the individual effects of the increasing number of chemicals, including pesticides, are relatively well-known, their impacts in combination remain largely unknown (Kuipers et al., 2014).

Growing antibiotic resistance, partly due to evolution though overuse and over prescription, and the widespread use of antibiotics in intensive animal rearing are also culpable, is increasingly of concern, but research is lagging (Kuipers et al., 2014; WEF, 2013). Concerns exist over the profitability of developing narrow-, rather than broad-spectrum drugs, and of a rich-country bias preventing medical spending that benefits the developing world.

Competition for global resources is expected to indirectly impact health. Continued exploitation of global fish stocks, for example, and increased ocean acidification could remove this critical food source from vulnerable populations — marine fish currently provide 6% of global protein (GMTs 9 and 10) (EMB, 2013).

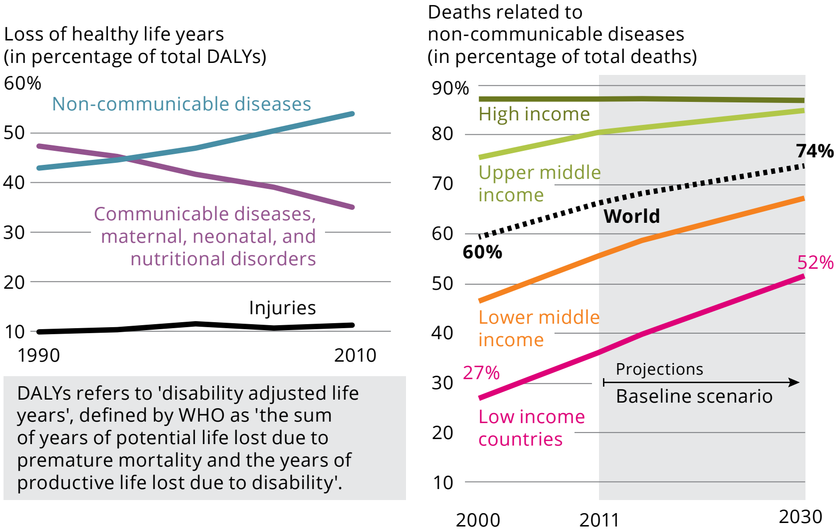
Trends

Non-communicable diseases: In 2008, NCDs accounted for 36 million premature deaths, and are likely to cause 55 million by 2030 (WHO, 2013c). Long predominant in developed countries, NCDs became the leading disease burden in developing countries in 2010 (Figure 3.3). Cardiovascular disease and cancers are the biggest cause of mortality worldwide (WHO, 2014a) and diabetes, to which the socially disadvantaged are most vulnerable, is projected to affect 471 million by 2035 (IDF, 2014). Senile dementia currently affects 44 million people and is projected to rise to 135 million worldwide by 2050, with 96 million of them in developing countries (ADI, 2013).

Lifestyle NCDs are increasing but are preventable — tobacco accounts for almost 6 million premature deaths a year, projected to rise to 8 million by 2030; around 3.2 million annually are attributable to insufficient physical activity and about 1.7 million to low fruit and vegetable consumption (WHO, 2014f).

Currently 10% of the world's adults are obese, and, in 2012, more than 40 million children under the age of 5 were either overweight or obese. In developing countries with emerging economies, particularly in urban areas, the rate of increase in these problems is 30% higher than in developed ones (WHO, 2014g).

Figure 3.3 **The change in the global burden of disease and share of non-communicable diseases by world regions, 1990–2030**



Source: GHDX, 2014 (left); WHO, 2014c (right).

Communicable diseases: In spite of the ongoing decline of communicable diseases (Figure 3.3), they still pose a significant threat to human health and international health security, especially in developing countries (WHO, 2011b). Even in developed countries, communicable diseases have not been completely eradicated, and in some cases their incidence is growing, mainly due to the emergence of drug-resistant disease strains. For example, tuberculosis has re-emerged in some developed countries where it had historically been reduced to very low levels (WHO, 2013b). In 2012, 8.6 million people globally were living with tuberculosis, and 1.3 million people died from it. In the same year, there were 35.3 million people living with HIV/AIDS worldwide, and 1.7 million people died of AIDS-related illnesses, including 230 000 children. Due to better access to therapy, the number of new HIV infections and deaths due to AIDS is decreasing globally, while the number of people living with HIV/AIDS is increasing (WHO, 2014d).

HIV/AIDS has received much attention in the developing world, but many developing countries face 'neglected tropical diseases', a group of parasitic and bacterial diseases such as dengue and leprosy. Vaccination programmes and other health responses for these diseases do exist, but they are often poorly and inadequately administered. Additionally, several contagious diseases persist despite the availability of an effective vaccine for over 50 years. One example is measles, a highly contagious disease that remains one of the leading causes of death among young children, particularly in developing countries.

Pandemics: Some infections have the potential to cause pandemics — made more likely by high levels of international travel and migration (IOM, 2013); the ability of some viruses to mutate rapidly and jump from animals to humans; and antibiotic resistance (Borer et al., 2009). The World Health Organization (WHO) warns that the world is 'ill-prepared to respond to severe pandemics ... threatening public health emergency' (WHO, 2011a).

Health inequalities: Although life expectancy and health have improved globally over the last decades, significant differences still exist between and within countries, urban and rural areas, and different income-level groups. Indeed, about 75% of all premature deaths in 2010 occurred in developing countries (Kuipers et al., 2014).

Health care services also vary: there are 33 physicians per 10 000 people in Europe, 5.5 in Southeast Asia and 2.5 in Africa. The high cost of medical care is another cause for concern — WHO suggests that around 150 million people face financial ruin each year from having to pay for medical services (WHO, 2013e).

Implications

Changes in disease burden could strain health systems and costs, deepen inequalities and increase poverty. If current demographic, urbanisation and health trends continue (GMTs 1 and 2) developing countries will have to deal with a multiple burden of NCDs, communicable disease and pandemics, especially in slums of burgeoning urban areas (WHO, 2013a).

The finances of developing countries may be threatened by NCDs — in countries in all income groups, productivity losses from NCDs are already greater than public health spending. In 2013, WHO warned that business-as-usual will increase productivity losses and health care costs everywhere, with the cost of inaction far outweighing that of taking action (OECD, 2012b; WHO, 2013a).

In developed countries, costs related to ageing populations and health could increase fiscal pressure and affect social cohesion and well-being (GMT 1) (De la Maisonneuve and Martins, 2013).

An integrated approach to health encompassing health inequalities, social, economic and environmental factors is key. Both WHO (2013a) and the United Nation Development Programme (UNDP, 2013) agree that improving human development requires increased investment in health as well as infrastructure, education, and governance.

With more than 70% of people projected to live in cities by 2050, good governance in urban areas will benefit both the environment and public health (EEA/JRC, 2013). In rural areas, the interactions of wildlife, domesticated animals and human health pose growing risks of disease, which should be tackled by addressing the connections between them and ecosystem health (Choffnes et al., 2012).

European countries improved public health in recent decades, and have relatively strong social safety nets and public healthcare systems. Nonetheless, significant health inequalities remain within and across countries — and have increased since 2006 (EC, 2013c), with poor families disproportionally affected by the recent economic crises (Kuipers et al., 2014). In Europe, including Russia, NCDs cause 86% of premature deaths (WHO, 2014h), with ambient air and noise pollution and antibiotic resistance of particular concern (EEA/JRC, 2013; EEA, 2014a).

The health impacts of climate change are of particular concern for the elderly and vulnerable (Lung et al., 2013) while rising temperatures are also likely to bring new vector-borne diseases (Kuipers et al., 2014). These factors, coupled with the increasing cost of long-term care and the decline in informal care for the elderly, threaten the affordability of technical advances, unless the EU addresses the underlying causes of ill health, including the influence of an ageing population, globalisation and environmental degradation (Choffnes et al., 2012; Kickbusch and Lister, 2006; Kuipers et al., 2014).

Accelerating technological change

The pace of technological change, particularly in the fields of information, communication, nano- and bio-technologies, is unprecedented. This provides opportunities to reduce humanity's impact on the environment and reliance on non-renewable natural resources, while improving lifestyles, stimulating innovation and green growth.

The risks associated with technological innovation should be minimised using the precautionary principle and regulatory frameworks. By recalibrating its institutions, policies and environmental knowledge base, Europe can support better risk management, while enhancing innovation and the diffusion of new technologies.

Drivers

Communication, collaboration and access to information all drive the acceleration of global technological change. Mass acceptance of technological change is also speeding up — electricity took almost half a century to reach 25% of the US population but the World Wide Web and smartphones took fewer than 10 years to achieve similar market penetration (Kurzweil, 2005).

The growth of developing region economies (GMT 6), driven in part by an increasing middle class (GMT 5), is creating new centres of innovation, heightening competition and shortening product innovation cycles. The prospect of significant returns on investment, particularly in emerging sectors, is also incentivising increased research and development (R&D).

Rising levels of education, particularly in developing regions (Samir et al., 2010), are boosting the human capital that underpins innovation (GMT 1). The Organisation for Economic Co-operation and Development (OECD) projects that, in coming decades, the number of young people with a tertiary education will be higher and grow fastest in such non-OECD G20 countries as Brazil, China and India (OECD, 2013a).

Urbanisation also drives innovation, facilitating the interactions needed to trigger and sustain it. This, however, depends on such factors as city planning and investment in infrastructure — as well as attracting skilled workers and engaging citizens.

Increasing scarcity of resources — from fossil fuels to critical raw materials — and concerns about climate impacts are also likely to both incentivise investment and shape technological and market developments. Past and current decisions also drive the direction of innovation, as inventions and technological change build on previous development (Biois, 2013a). This path dependency can constrain options and close down development, including innovation that might offer promising or useful solutions to societal challenges or needs (von Schomberg, 2013).

Trends

Cycles of technology-induced societal and economic change have accelerated in past decades, and are very likely to accelerate further. Indeed, there is evidence of exponential rather than linear growth for some technological progress (Box 4.1).

Box 4.1 ICT's exponential increase

The central functions of information and communication technologies (ICTs) — processing, storing and transferring information — have all shown exponential increases in performance relative to costs. One megabyte of computer memory cost almost USD 1 million in 1970, but this dropped to well under USD 100 in 1990 and USD 0.01 in 2010. The number of transistors that can be squeezed on to a given chip continues to double in a period of less than two years, as it has done since the invention of integrated circuits in the late-1950s. In just a few years this has translated into enormous increases in processing power (McCallum, 2014).

Innovation is becoming more global. Europe trails the US and Japan in terms of global innovation performance, but remains ahead of others, although South Korea and China are developing rapidly (EC, 2014c). North America and Europe will remain important centres of R&D, but there is a shift in the technological centre of gravity to fast-growing countries of Asia and Latin America (NIC, 2012). India, South Korea and particularly China are already increasing their share of patent filings, simultaneously providing markets for new products (WIPO, 2014). Many observers agree that much of the next long-term wave of innovation and growth will be formed by a cluster of rapidly emerging nanosciences and nanotechnologies, biotechnologies and life-sciences, ICTs, cognitive sciences and neurotechnologies — the NBIC cluster (Box 4.2) (Nightingale et al., 2008; Silberglitt et al., 2002).

Although the acceleration of innovation and technological change is stable, its direction is uncertain. Besides technological constraints — many NBIC technologies are still in the laboratory — key uncertainties relate to R&D funding and public policy development. Intellectual property regimes and the way they may shape development are also a major concern across new technologies (Biois, 2013a).

Box 4.2 The NBIC cluster

The NBIC cluster is moving rapidly from development to application (Nightingale et al., 2008).

Nanotechnology involves the manipulation of materials at atomic, molecular and supramolecular scales to produce nanomaterials with desirable properties such as greater reactivity, unusual electrical properties or enormous strength per unit of weight.

Biotechnology refers, broadly, to the application of science and technology to living organisms (OECD, 2005), in particular their genomes, including synthetic biology. Biotechnology has contributed to a broad range of existing applications including agriculture and food, medicines, health diagnostics and treatments, and enzymes for a variety of industrial applications (JRC/IPTS, 2007).

Information and communication technology (ICT) has become pervasive, affecting a huge number of sectors and transforming the process of technological development itself. These technologies allow citizens across the world to collaborate and provide access to unprecedented amounts of data and information. Together with developments in cognitive sciences and neuro-technologies these technologies give raise to a range of applications such as prosthetics limbs, brain-machine communication and artificial intelligence.

Biotechnology is already addressing treatments for such conditions as dementia, and could yield drugs to enhance natural capacities (Biois, 2013a). Genetic research is looking to regrow organs and even improve them, while genetic screening could contribute to disease prevention.

Agricultural biotechnology, including genetically modified crops, has been applied globally, raising societal issues regarding food security, human and animal health, and ethics. By 2040–2050, nano- and biotechnologies will be pervasive, diverse and integrated into all aspects of life. This may have far-reaching implications for such areas as the control of matter and genes, human-computer interactions, food production, healthcare, and the environment (Subramanian, 2009).

Implications

New technologies bring opportunities and risks for both people and the environment — particularly evident for the NBIC cluster in terms of the environment and health (Biois, 2013a; Silberglitt et al., 2002). Nanotechnologies, for example, provide an ability to innovate at atomic and molecular scales, potentially, for example, enhancing the detection and remediation of illnesses or environmental deterioration or the production of better materials at lower cost.

Risks associated with technological advances are, however, often underestimated or ignored, resulting in considerable social and economic costs (EEA, 2001, 2013c). Furthermore, technologies and resource uses that rely on substantial investment in infrastructure and materials are often difficult to reverse. The development of more integrative risk assessment frameworks that acknowledge and address critical uncertainties, and the indirect benefits and cost of adoption, are critical for informed decision-making. Where technologies carry uncertain but socially acceptable risk, public and corporate management regimes are of critical importance (Renn and Roco, 2006). Emphasis on the precautionary principle as a science-based approach for coping with uncertainty could help avoid irreversible social and environmental impacts.

As the behaviour of nanoparticles in the environment is unknown, their application is likely to raise concerns. Nanoparticles' rapid transformation could, for example, render traditional approaches to describing, measuring and monitoring air or water quality inadequate (RCAP, 2008).

Biotechnology also raises profound issues regarding the value of life and the extent to which living organisms should be manipulated (Manyika et al., 2013).

Potential applications include developing biofuels, vaccines and antibodies; understanding cancer; minimising carbon footprints; and improving crops. But biotechnology could produce both intended threats — bioweapons — and unintended ones from its use in medicine or food production.

Social acceptance will play an important role in shaping the use and regulation of new technologies. As low levels of public acceptance can slow or stop innovation, new governance and institutional arrangements that accommodate different perceptions of risk and societal views are needed. Some tools are emerging, emphasising responsible research and innovation serving socially desirable needs (von Schomberg, 2013).

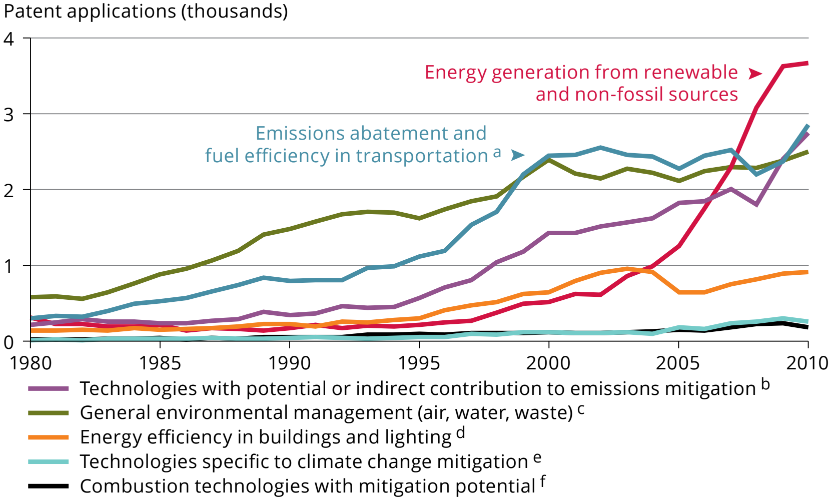
New technologies have a part to play in the shift towards resource-efficient, low-carbon economies (UNEP, 2011b). Examples include nanotechnologies for energy conversion and storage; replacement of toxic materials; new, lighter materials; environmental remediation (UBA, 2010); and the use of enzymes in renewable energy production. Since the early 1990s, environment-related applications to the European Patent Office have steadily increased, with those targeting emission mitigation and energy showing significant growth (Figure 4.1).

Efficiency gains can sometimes fail to reduce environmental pressures, however, because they often make products cheaper, effectively increasing consumer spending power. Reducing environmental pressures therefore requires complementary measures that also address consumption (EEA, 2015b).

Technological advances that enable machines to perform human tasks could have implications for society, in particular influencing inequality. Increasing use of machines may depress wages for some, while boosting demand for highly skilled labour and low-skilled service-sector work. The resulting polarisation of job opportunities could contribute to greater earnings inequality (Autor, 2010; Goos et al., 2009).

By reducing demand for labour relative to machinery, new technologies can also mean that returns to production increasingly accrue to the owners of physical capital. In most countries and industries, labour's share in national income has declined significantly since the early-1980s and this has been attributed to advances in ICT (Karabarbounis and Neiman, 2014). While

Figure 4.1 **Environment-related patent applications to the European Patent Office, 1980–2010**



Note: The graph shows the development in total patent applications (direct and patent cooperation treaty national phase entries); for the world's seven largest filing offices.

a. Technologies specific to propulsion using internal combustion engine (ICE) (e.g. conventional petrol/diesel vehicle, hybrid vehicle with ICE); technologies specific to propulsion using electric motor (e.g. electric vehicle, hybrid vehicle); technologies specific to hybrid propulsion (e.g. hybrid vehicle propelled by electric motor and internal combustion engine); fuel efficiency-improving vehicle design (e.g. streamlining).

b. Energy storage; hydrogen production (from non-carbon sources), distribution, storage; fuel cells.

c. Air pollution abatement (from stationary sources); water pollution abatement; waste management; soil remediation; environmental monitoring.

d. Insulation (including thermal insulation, double-glazing); heating (including water and space heating; air-conditioning); lighting (including compact fluorescent lamps, light-emitting diodes).

e. Capture, storage, sequestration or disposal of greenhouse gases.

f. Technologies for improved output efficiency (combined combustion); technologies for improved input efficiency (efficient combustion or heat usage).

Source: OECD, 2014b.

many NBIC technologies are still in the laboratory, others, such as 3D printing (Box 4.3), are already on available or close to large scale roll-out and are bound to have major economic and environmental impacts.

Box 4.3 Additive manufacturing

The central functions of information and communication technologies (ICTs) — Additive manufacturing or 3D printing is a process for making three-dimensional solid objects from digital models. Future advances in layering techniques and materials are expected to enable increasingly complex goods to be printed at lower costs. Such goods could include genetically engineered bio-materials. 3D printers are increasingly being used to produce objects ranging from the nano-scale to large items such as car prototypes. Mass uptake in coming years is likely to have disruptive impacts on a range of sectors, including retail, logistics and freight transport at the global and local levels (Campbell et al., 2011).

Opportunities for mass customisation of goods are also likely to affect consumption patterns (EU, 2014). The widespread use of 3D printing could help enhance the efficiency in terms of energy and resource use. However, the possible delivery of raw materials to the final consumer could counteract this effect. Moreover, home printing of personalised foods or other goods, including toys, electrical fittings, medicines or weapons, that pose risks to life, health or the environment could create serious risks (Foresight, 2013). The highly decentralised nature of 3D printing may make the design and enforcement of regulations to manage such risks a challenge.

As much new technology with the potential to being disruptive is already available, preventive and proactive responses to deal with emerging problems and changing socio-political and environmental landscapes should become a priority, both in Europe and the rest of the world. The precautionary principle should help shape innovation towards societal utility, environmental desirability and sustainability.

When considering options, societal problems can also be viewed as opportunities. This approach fosters new ideas that may stimulate innovation and ways of thinking, including regarding the types of institutions and policies that can best support innovation and its use.

Vulnerabilities are created when policies do not keep up with the opportunities and threats of unfolding dynamics, conditions and realities of socio-technological systems. Thus, a key consideration for innovation governance is an ability to react, learn and adapt. New governance paradigms that emphasise reflexivity create capacities for adaptive decision-making — interventions essential for coping with emerging impacts.

Continued economic growth?

Economic output is projected to treble between 2010 and 2050, although growth is expected to decelerate in many countries as they become more prosperous. Rapid economic growth has brought reductions in global poverty and increases in well-being but it is also linked to growing inequality and escalating environmental pressures. In Europe, slowing growth is straining public finances for environmental protection and increasing inequality.

The limitations of gross domestic product (GDP) as a measure of human well-being and the sustainability of growth have prompted international efforts to identify better indicators of societal progress.

Drivers

Globally, countries are continually seeking ways to stimulate economic growth as a means of providing jobs and improving living standards. At the most basic level, economic output depends on population size and output per person; each has accounted for about half the global economic growth since 1700 (Maddison, 2013).

While population growth is linked to fertility, mortality and migration rates (GMT 1), productivity has more complex determinants. Today it is understood to depend on the development of four key forms of capital: human (knowledge, skills and health); social (trust, norms and institutions); manufactured (machinery and infrastructure); and natural (resources and ecosystems) (World Bank, 2006).

Often these capitals are complements, with the value of one dependent on the presence of another. For example, if natural resource wealth is not accompanied by effective state institutions, it can fuel corruption and weaken competitiveness, thereby undermining economic growth (Rodrik et al., 2004). Equally, investments that augment manufactured capital are likely to be counter-productive if they degrade essential environmental systems. As Daly has observed, 'what good is a sawmill without a forest?' (Daly, 1992).

Technological and social innovation plays a key role in the development of capital stocks, driving long-term growth. Examples include the development of tools and machinery, and aggregation of labour and businesses in urban settings, and the division of production processes into multiple stages handled by different workers. Such innovation increases productivity — enabling society to maximise the economic returns on finite inputs of labour and resources. Innovation is also at the core of structural economic change — the transition from largely agrarian economies through industrialisation to largely service-based structures.

As a result of innovation and investment, several of the capital stocks underpinning economic output have been increased markedly in recent decades. In developed countries, manufactured capital was worth 2.0–3.5 years of national income in 1970 but increased to 4.0–7.0 years of national income by 2010 (Piketty and Zucman, 2014). Workforces also expanded. The global population of those aged between 15 and 64 tripled to 4.54 billion in the period 1950–2010 (UN, 2013b). Education, skills and human health are also improving, particularly in developing regions (GMTs 1 and 3). At the same time, however, natural capital is increasingly under pressure (GMTs 8, 9 and 10).

Trends

The spread of global growth

Rapid economic growth is a comparatively recent phenomenon. Productivity increases were negligible before 1700, implying that economic output rose no faster than the very modest rate of population growth — about 0.1% annually. In the 18th century, however, the agricultural and industrial revolutions in Western Europe caused a fundamental shift, initiating a steady acceleration of economic growth. By the first half of the 20th century, average annual global GDP growth had reached 2% and this rose to 4% in the period 1950–2008. As a result, world economic output increased 25-fold in the period 1900–2008 (Maddison, 2013).

Global growth in recent decades was made possible by the exceptionally rapid economic expansion in some very large developing countries, which were able to import knowledge, practices and technologies rather than going through the slower process of developing them domestically. China is the most important example — its economy grew by an average of 9.8% per year in the period 1980–2013, doubling in size every seven years (World Bank, 2014b).

The financial crisis of 2008 and subsequent economic turmoil had a major impact on economic growth globally. Developed regions were hit hardest. In 2013, for example, the EU's economic output was still 1% below its 2007 level (World Bank, 2014b). Major developing countries including Brazil, Russia and South Africa also endured recessions, while others — notably China, India and Indonesia — faced an appreciable slow-down in growth.

Many emerging economies have since proven to be remarkably resilient, however, sustaining global growth despite stagnation is most advanced economies. In 2007–2013, India's GDP increased by 46% and China's by 68% (World Bank, 2014b). As a result, the financial crisis greatly advanced the rebalancing of economic production across the world (GMT 6).

Decelerating growth

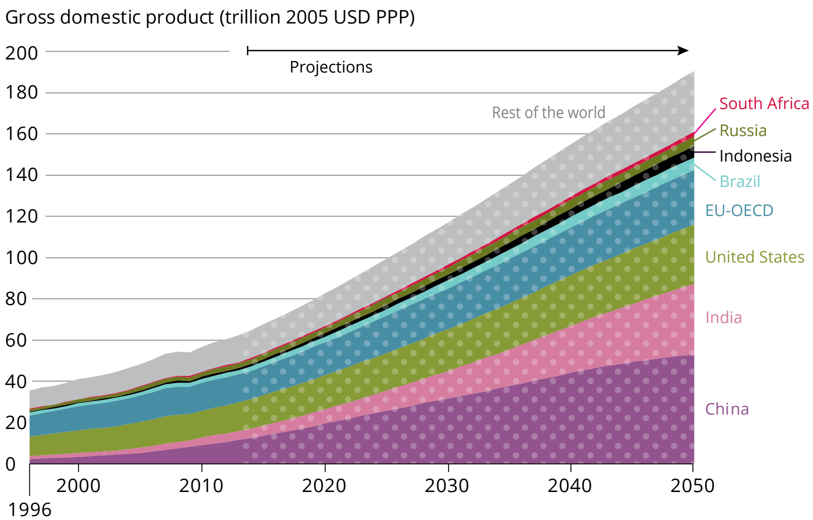
Following the 2008 financial crisis, many uncertainties surround the short-term outlook for global growth. These include, for example, concerns about the quality of the domestic investment that have helped sustain China's growth since 2008, and worries about the prospects for continued economic integration in Europe, especially among the countries using the euro.

Although annual growth rates may remain volatile, however, the broad direction of global growth appears clearer in the medium and long term. World economic growth is projected to remain robust in coming decades as investment in human, social and manufactured capital enable other countries to follow in China's footsteps. The Organisation for Economic Co-operation and Development (OECD) projects that global GDP will almost triple in the years 2010–2050 (Figure 5.1).

In 2013, GDP per capita (PPP) in China stood at 22% of the US level, while India's stood at 10%. As those countries' huge populations continue to shift towards the systems of production and consumption present in today's advanced economies, the expansion in GDP is likely to dwarf even that achieved by the US during the past century. By 2050, India's economic output is projected to be just 14% smaller than US economic output while China's is projected to be 40% larger.

Global economic growth is expected to decelerate steadily in the coming decades, however, from a postcrisis peak of 4.3% in 2017 to just under 2% a year in 2050. Economic expansion in China is projected to slow particularly sharply, from an average of 7.9% a year in 2010–2020 to 1.9% in 2040–2050. Meanwhile, India is expected to become the fastest growing economy among Brazil, Russian, India, Indonesia, China and South Africa (BRIICS), with an average annual increase of 5.9% in 2010–2050, although there too it is projected to slow to below 4% by the end of the period. In the EU,

Figure 5.1 Past and projected global economic output, 1996–2050



Note: EU-OECD refers to the EU Member States that are also members of the OECD. These countries accounted for approximately 97% of EU-28 GDP in 2012.

Source: OECD, 2014a.

demographic trends are projected to contribute to a fall in GDP growth, from 1.7% a year in 2020 to 1.3% in 2050 (OECD, 2014a).

Implications

Poverty alleviation in developing regions

The combination of rapid economic growth in developing regions and much slower growth in advanced economies creates a mixture of opportunities and concerns.

While the link between GDP and human well-being is undoubtedly complex, it is clear that economic expansion delivers a range of important benefits for society. Growth plays an important role in determining household earnings and sustaining employment levels. Equally, economic performance shapes the revenues available to governments and, correspondingly, the resources available for public infrastructure and services such as education, healthcare and various forms of social security.

There is much evidence that economic growth in recent decades has delivered substantial improvements in living standards. The poverty gap — the proportion of the population living on less than USD 1.25 a day — fell globally, although the pace varied between regions. The fastest reduction was in the developing countries of east Asia and the Pacific, where the proportion fell from 35% in 1981 to just 2.8% in 2010. This performance contrasted sharply with the developing countries of sub-Saharan Africa, where the proportion increased from 22% in 1981 to 26% in 1996, before falling back to 21% in 2010 (World Bank, 2014b). Nevertheless, the percentage of the global community living on less than USD 1.25 a day fell from 47% in 1990 to 22% in 2010 — a reduction of about 700 million people (UN, 2013a).

Managing inequality and environmental degradation

Economic growth in both developing and developed regions is also associated with social and economic harm that threatens to undermine improvements in living standards. One key concern relates to the distribution of wealth and incomes. Although the rapid growth of developing regions is reducing inequality of living standards at the global scale, the trends within countries often show the opposite. For example, the shift away from planned economies in countries such as Russia and China has brought greater inequality, as has the explosion of executive salaries in the US and other advanced economies (UNDP, 2013; Stiglitz, 2013).

Increased inequality has long been recognised as a potential side-effect of industrialisation, with wage disparities widening as a portion of the population moves from agricultural activities to more productive urban work (Kim, 2008). Later stages in structural economic change tend to see a convergence of rural and urban wages. Recent analysis suggests, however, that the sluggish growth in many advanced economies could augment inequality by leading to the accumulation and concentration of wealth (Piketty, 2014). Technological advances may further augment inequality (GMT 4). Mitigating the inequities that can arise from economic growth trends is, therefore, a governance challenge at all stages of economic development.

Another concern relates to the links between the economic growth and environmental degradation. Although in many areas resource efficiency is increasing, the scale of economic activity globally is pushing resource use and emissions to higher absolute levels (GMTs 7, 8, 9 and 10), with potentially huge impacts on natural cycles. The interdependence of global environmental systems means that individual countries and regions, including Europe, are increasingly affected by action elsewhere.

While slower growth in the EU and elsewhere may alleviate environmental pressures, it also brings social and environmental risks (Everett et al., 2010). In some EU countries, an expected rise in dependents relative to the working population is likely to undermine labour tax revenues while boosting the demand for pensions and public health expenditure (EC, 2012b). And while the accumulating wealth that may accompany slow growth could provide an alternative tax base, governments face some difficulties in raising revenues from this source as liberalised financial markets enable investment and profits to shift to countries offering lower taxes (Piketty, 2014). Taken together, these fiscal pressures could weaken investment in environmental protection and motivate governments to relax environmental standards in order to boost economic growth.

Moving beyond GDP

Worries about the social and environmental harm that can arise when governments focus too narrowly on economic growth have directed attention to the need for better measures of human well-being and economic robustness. Quality of life, it is argued, is shaped by numerous factors that are at most partially related to economic output. These include health, time with friends and family, access to resources and a pleasant living environment, education, social equity, leisure, political participation, and personal and economic security.

Equally important, GDP provides little indication of the status of the capital stocks that underpin output; indeed, focusing just on GDP growth actually creates incentives to deplete capital stocks because the returns are treated as income.

A number of processes have been initiated in recent years to develop better indicators of progress by integrating environmental and social components. These include the EU's Beyond GDP initiative (EC, 2009a, 2013e), the Commission on the Measurement of Economic Performance and Social Progress initiated by the French government in 2008 (CMEPSP, 2013), the United Nations Human Development Index (UNDP, 2014a), and the OECD Better Life Index (OECD, 2013b). Stiglitz et al. (2009) capture the current mood with the observation that 'the time is ripe for our measurement system to shift emphasis from measuring economic production to measuring people's well-being'.

An increasingly multipolar world

Driven by structural change, fast-growing workforces and trade liberalisation, developing regions are rapidly increasing their share of global economic output, trade and investment.

For Europe, this rebalancing presents competitive threats but also economic opportunities in meeting the demand of a fast growing global middle class. The emergence of a larger and more diverse mixture of major economic powers may, however, complicate global efforts to coordinate governance. And growing economic interdependence will make it harder to manage the social and environmental impacts associated with production and consumption systems.

Drivers

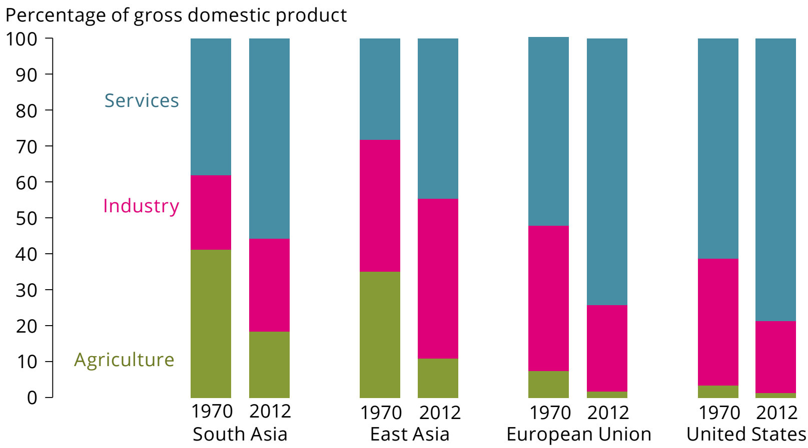
Structural convergence

Globally, economic power is shifting. Due to contrasting rates of growth, developing regions are gaining in importance and developed regions are becoming less dominant. These trends are linked to the process of structural economic development: the transition from agrarian societies, through industrialisation to service-based and knowledge economies.

In developed regions, industrialisation in the 19th and 20th centuries brought an unprecedented increase in economic output. Today, developing regions are undergoing the same transition but at much faster rates because they have been able to import and adapt existing approaches. In some countries, the process is already advanced; in 2012, the economic structure of East Asia and the Pacific was similar to the EU's in 1970 (Figure 6.1).

In contrast to the rapid growth in developing regions, structural and demographic factors have slowed growth in the advanced economies. The increasing contribution of services to economic output is important, since many branches of the service sector deliver modest productivity growth (Marota-Sanchez and Cuadrado-Roura, 2011). At the same time, lower birth rates mean that populations in many developed countries have stopped growing or started contracting, and labour forces are expected to decline further as the population ages (GMT 1).

Figure 6.1 **Structural breakdown of economic output in selected regions, 1970 and 2012**



Note: The graph shows the contribution of service, industry and agriculture to aggregate economic output. The composition of regional groupings corresponds to World Bank definitions (World Bank, 2014a).

Source: World Bank, 2014b.

Factors affecting convergence

Trade liberalisation has contributed to the rebalancing of global economic output. Access to export markets promotes structural economic change because national production is no longer limited by domestic demand. Instead, a country can expand output of goods or services that it can produce relatively cheaply, thereby boosting aggregate productivity. In developing countries, that often means increasing labour-intensive manufacturing.

The average level of tariffs on manufactured products in industrialised countries has dropped from 45–50% in 1948 to an average of about 3% in 2009 (Krueger, 2009). World exports grew at an average rate of 7.9% per year between 1990 and 2011, while global gross domestic product (GDP) increased by about 5.5% (in nominal terms) annually (World Bank, 2014b).

Foreign direct investment (FDI) also contributes to structural change because, in addition to financing accumulation of productive capital, it is associated with the diffusion of technologies, skills, institutions and management expertise (OECD, 2002). Some developing countries have facilitated technology transfer and the transition to post-industrial economic structures though major investments in education and health (GMT 2).

While the processes of socio-economic development tend to cause economic productivity to converge across the globe, there are many uncertainties. Socio-political developments within developing countries — for example democratic processes and growing income disparities — are very hard to anticipate, as are the effects of shortages of skilled labour due to demographic changes — migration and ageing, for example. In terms of international relations, uncertainty surrounds the ability of emerging countries to develop economic cooperation mechanisms. Perhaps most important are the risks of geopolitical instability and military conflict.

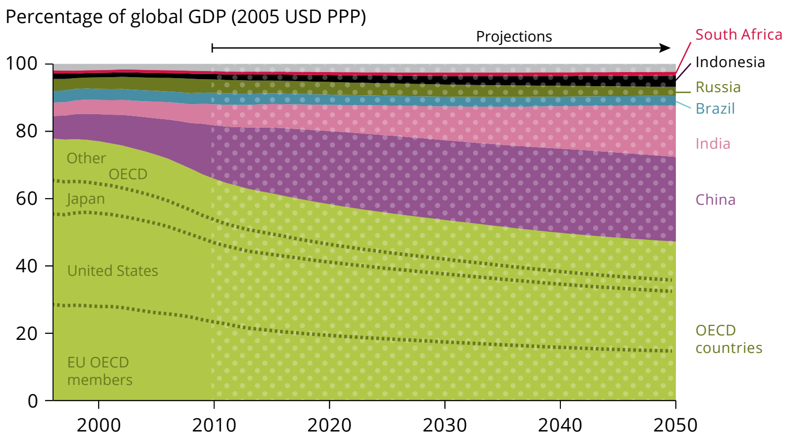
Trends

Declining dominance of advanced economies

Projections of global GDP underline the increased economic significance of today's developing and emerging economies. In 2000, the Organisation for Economic Co-operation and Development (OECD) member countries accounted for less than 20% of the global population but 77% of its economic output, but this is projected to fall to 50% in 2030 and 42% in 2050 (Figure 6.2). The EU's share is projected to drop by around half between 2000 and 2050, falling from 28% to 14% (OECD, 2014a).

In the short term, the financial crisis and subsequent economic stagnation in advanced economies has accelerated the global convergence of living standards (GMT 1). Even when steady growth returns to the EU, it is projected to be modest compared to the expansion in developing regions. By 2017, China is expected to have the world's largest economy, in purchasing-power parity (PPP) terms, although its share of global GDP is expected to wane slightly after 2045. India is likely to achieve similar growth, though from a significantly lower base, with its share of global economic output projected to rise from 4.3% in 2000 to 18% in 2050 (OECD, 2014a).

Figure 6.2 Contribution of major economies to global GDP, 1996–2050



Source: OECD, 2014a.

Trade and investment

The increasing importance of emerging countries is also apparent in world trade, with the larger advanced economies becoming less dominant in the three decades up to 2012 and China, in particular, emerging as a major exporter. Excluding intra-EU trade, the EU accounted for 15.4% of global merchandise imports in 2012 and 14.7% of exports (WTO, 2014a). These figures were comparable to the contributions of the US (12.5% of imports and 8.4% of exports) and China (9.8% of imports and 11.1% of exports). In general, external trade plays a large role in the economic output of the emerging economies, since agriculture and manufactured goods are more easily traded than services.

Looking ahead, global trade flows are likely to continue evolving. There are also some indications that rising wages in China are weakening its competitive advantage in some sectors. Some labour-intensive manufacturing industries have already relocated to other Asian countries and more are likely to follow (Accenture, 2011; FT, 2012). So, while China's trade is likely to increase in absolute terms in coming decades, other countries may displace it in certain sectors.

The global economy has also become more balanced in recent decades in terms of investment flows. Foreign direct investment has expanded enormously, from 0.4% of world GDP in the 1970s to 2.6% in the 2000s. At the same time, advanced economies have become less dominant, with the combined contribution to global FDI of the US, EU-27, EFTA and Japan declining from almost 100% in the early 1970s to 60% in 2012. Motivated by a desire to secure access to resources, technologies, expertise and brands (Fontagné and Py, 2010), China's outward investment has grown enormously in recent years, accounting for 12.1% of global FDI in 2012.

Implications

Economic risks and opportunities for developed regions

Emerging economies have competitive advantages in low-skilled, labour-intensive production. This creates a competitive challenge for advanced economies, putting downward pressure on wages for low-skilled workers in Europe and other developed countries (Autor et al., 2012).

At the same time, however, increasing prosperity in developing regions potentially offers a growing, wealthy customer base for exports in areas of European specialisation, such as scientific innovation and luxury brands. The global middle class — defined as households with daily available funds of USD 10–100 (PPP) per person — is projected to increase from 27% of the world population of 6.8 billion in 2009 to 58% of more than 8.4 billion in 2030 (GMT 2). The Asia-Pacific region is projected to provide much of this growth, accounting for 66% of the total world middle-class population in 2030, up from 28% in 2009 (Kharas, 2010). In addition to changing consumption patterns, this is likely to bring with it evolving norms, attitudes and expectations, with potentially far-reaching implications for social cohesion and political systems (Pezzini, 2012).

In the long term, continued economic progress in developing regions may cause their cost advantages to disappear, ultimately leading to the repatriation ('back-sourcing') of some production to today's advanced economies. Although these changes will expose advanced economies to increasing competition in areas in which they currently dominate, such as high-tech industries or financial services, the restructuring of emerging economies towards largely non-traded services as they become wealthier may alleviate some competitive pressure.

New actors and new challenges in global governance

Until relatively recently, coordination of the international economy was largely handled by the small group of structurally similar states that accounted for most global production. The financial crisis of 2008 exposed a changing reality. Today, choices by large emerging economies — for example relating to the accumulation of foreign currency reserves — can have major effects on the entire global economy.

The decline of the G7/G8 and the emergence of the G20 as the locus of global economic planning reflect this transition. Brazil, Indonesia, Mexico, South Korea and Turkey, for example, now have a more important role in global governance. China and India are already major economic powers with related global social and environmental impacts and responsibilities. Yet they have acquired this status when their average per person income levels are quite low. They therefore face a set of internal development challenges and demands that are quite different from advanced economies (Spence, 2011).

The systemic importance of large emerging economies means that their engagement in international economic governance is essential. But the growing number and diversity of participants are also likely to make it harder to coordinate global activities and ensure economic stability. The EU will remain a powerful voice in these processes but its capacity to control external risks may decline.

The need for coordinated environmental governance is also growing as economic and social interactions intensify. Globalisation of trade flows has created economic benefits for exporting and importing countries but it also means that consumers are extremely unlikely to comprehend the full social and environmental implications of their purchases. National governments have very limited capacity to monitor or manage such impacts, in part because the international agreements that facilitate global trade prevent states from differentiating between imports based on production methods (WTO, 2014b).

To some extent, the harm associated with globalised supply chains may abate as growing prosperity in developing regions brings popular demand for improved local environmental and social protection. However, such advances may do little to curb pressures on the global environmental commons.

At present, therefore, the international community lacks effective institutions to coordinate its response to complex globalised challenges such as climate change and international financial instability. This is creating demand for new forms of governance (GMT 11).

Intensified global competition for resources

Global use of material resources has increased ten-fold since 1900 and is set to double again by 2030. Escalating demand may jeopardise access to some essential resources and cause environmental harm. Uneven geographical distribution of some resources could further increase price volatility, undermining living standards and even contributing to geopolitical conflict.

For Europe this is a major concern as its economy is structurally dependent on imports. Although growing scarcity and rising prices should incentivise investments in technologies to alleviate supply risks, such innovations will not necessarily reduce environmental pressures.

Drivers

Global demand for resources has increased substantially since the start of the 20th century, driven by a number of closely related trends. Across the world, countries have undergone structural economic change, shifting from agrarian societies, primarily reliant on biomass to meet energy and material needs, to urban, industrialised economies (GMT 2).

The technological advances that accompanied economic development have provided many more uses for resources, and greatly improved methods for locating and extracting them. Coupled with a quadrupling of the world's population in the 20th century (GMT 1), innovation has underpinned a 25-fold increase in economic output (GMT 5), bringing radical changes in consumption patterns.

Looking ahead, the global population may increase by more than a third by 2050, reaching 9.6 billion (UN, 2013b). World economic output is projected to triple in the period 2010–2050 (OECD, 2014a). And the middle class may increase from 27% of the world population of 6.8 billion in 2009 to 58% of more than 8.4 billion in 2030 (Kharas, 2010).

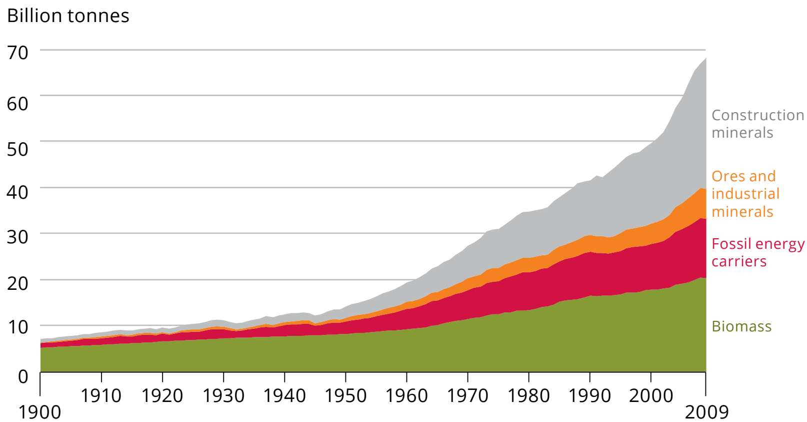
At the same time, however, some of the drivers of past increases in resource use could alleviate demand in the future. For example, continued structural economic change — away from industrialised systems and towards services and the knowledge economy – could offer ways to decouple further economic growth from resource use. Similarly, a continued shift from diffuse rural living to compact urban settlements could translate into less resource-intensive lifestyles (GMT 2).

Trends

Intensifying global demand

Global materials use is estimated to have increased almost ten-fold since 1900, accelerating from annual growth of 1.3% in 1900–1949, to 2.6% in 1950–1999, and 3.6% annually in 2000–2009 (Figure 7.1) (Krausmann et al., 2009). Developing regions account for an increasing proportion of global resource use. Whereas Europe was responsible for 19% of total resource extraction in 1980 and the US accounted for 18%, by 2009 both had fallen to 10%. Asia's share increased from 41% to 57% over the same period (SERI, 2013).

Figure 7.1 Global total material use by resource type, 1900–2009



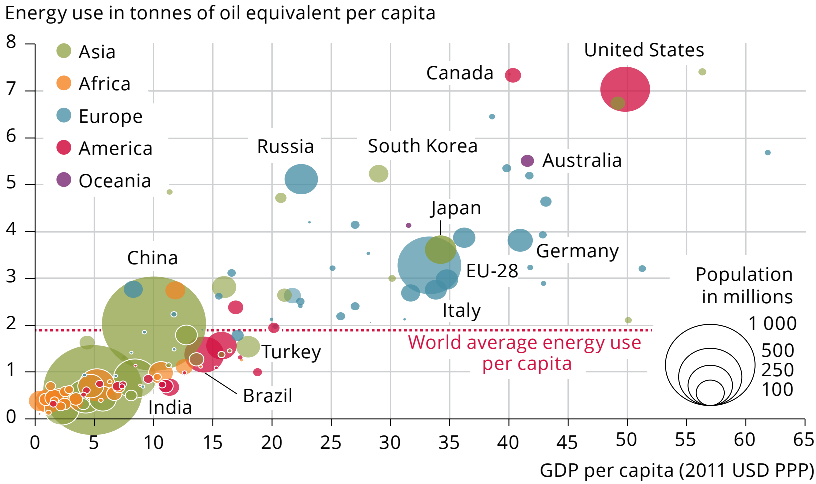
Source: Krausmann et al., 2009 (data updated in 2011).

Resource use tends to rise as countries develop economically. However, there is evidence that growth slows or ceases at high income levels, as a consequence of reduced investment in infrastructure, structural economic change, efficiency improvements and the relocation of some manufacturing to countries with lower labour costs.

International Monetary Fund analysis, for example, indicates that consumption of base metals and steel rises in step with per person gross domestic product (GDP) but reaches a saturation point at USD 15 000–20 000 (2000 PPP), except in countries, such as South Korea, where industrial production and construction continue to play a major role in economic growth (IMF, 2006).

Consumption of energy resources follows a similar pattern. Cross-country analysis shows a strong correlation of energy use to economic output (Figure 7.2). Yet in many developed countries energy use has been stable for some decades, albeit at very different levels. In 2012, the citizens of EU-28

Figure 7.2 Correlation of energy consumption and GDP per person, 2011



Note: The graph shows the correlation of national per capita energy consumption and per capita GDP. The size of the bubbles denotes total population per country. All values refer to the year 2011.

Source: World Bank, 2014c.

Member States consumed roughly the same amount of energy as they did in the late-1970s. In the US, energy use per person has changed little in almost half a century, while GDP per person has more than doubled.

While these trends indicate a huge improvement in energy efficiency, it is clear that advanced economies remain very resource intensive. If developing regions adopt similar systems of production and consumption it will have huge implications for global resource demand. For example, if the current global population increased average energy use to EU levels it would imply a 75% increase in world energy consumption, while an increase to US levels would imply a 270% rise.

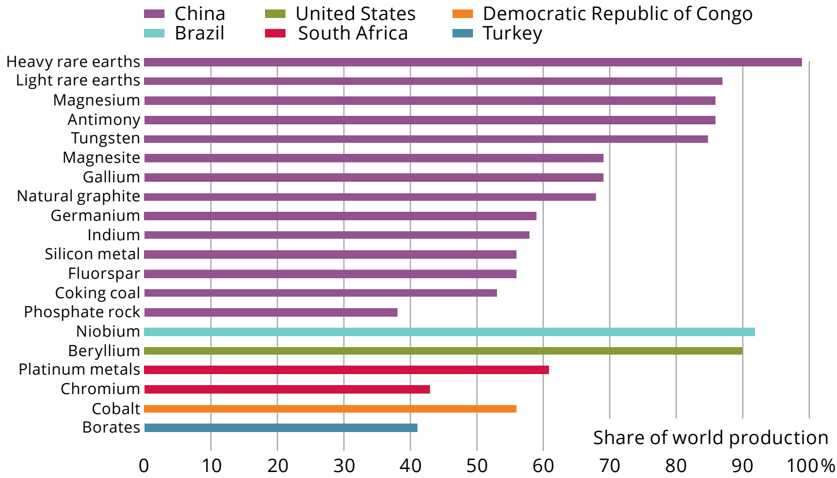
Projections of future resource use indicate that developing regions will drive up global resource demand in coming decades. The Sustainable Europe Research Institute (SERI) expects world resource use to double between 2010 and 2030 (SERI, 2013). The International Energy Agency projects that global energy consumption will increase by 31% in the period 2012–2035, based on energy policies in place in early-2014 (IEA, 2014).

Uncertain access to critical resources

While global demand for resources is set to grow significantly in coming decades, the outlook for supplies is more uncertain. Geographic concentration of reserves in a limited number of countries is a concern since it affords suppliers considerable influence over global prices and supplies, as illustrated by the influence of the Organization of Petroleum Exporting Countries over global oil markets. Uncertainty regarding access to commodities increases if reserves are concentrated in politically unstable regions.

Certain non-renewable resources deserve particular attention because of their economic relevance, including their role in green-energy technologies. In 2014, the European Commission identified twenty critical raw materials, based on the risks of supply shortage and their economic importance to Europe (EC, 2014b). Global production of these materials is quite concentrated (Figure 7.3).

Figure 7.3 Proportion of global production of EU critical raw materials within a single country, 2010–2012



Note: The graph shows the 20 raw materials identified by the European Commission as being critical because of risks of supply shortages and their impact on the economy.

Source: EC, 2014b.

Identifying alternative resource streams

Uncertainty about resource supplies can create strong incentives for countries to identify other ways to meet their resource needs, either by locating new sources of traditional resources or identifying substitutes. For example, rising fossil fuel prices, coupled with state efforts to promote alternatives, have incentivised huge investment in renewable energy in recent years. Global investment rose from USD 40 billion in 2004 to USD 214 billion in 2013. Renewable power capacity, excluding hydropower, increased more than six-fold in this period (REN21, 2014).

As well as facilitating a move towards other energy sources, technological advances have also boosted access to fossil fuels. Estimates of reserves evolve rapidly as new deposits are discovered and innovation allows previously unusable or unreachable reservoirs to be exploited, for example via deep water drilling and the extraction of shale gas and oil. Indeed, proven global reserves of oil and gas have increased substantially since

1980 — faster than consumption of either resource. As a result, the number of years that proven oil reserves would last at current rates of consumption has increased from 30 to more than 50 years (BP, 2013).

Implications

Insecure access to essential resources and price volatility are threats to economic development and living standards. Global commodity prices have spiked repeatedly in recent years, reversing long-term downward trends (World Bank, 2013). Such uncertainty represents a clear risk to the European economy, which is dependent on imported resources, particularly metals and fossil fuels (EEA, 2012b).

In addition to economic risks, attempts to secure access to resources can foster insecurity and conflict (Garrett and Piccinni, 2012). Tensions can arise in connection with competing claims over resource stocks or, less directly, as a result of attempts to restrict trade flows. As the World Trade Organization notes, 'in a world where scarce natural resource endowments must be nurtured and managed with care, uncooperative trade outcomes will fuel international tension and have a deleterious effect on global welfare' (WTO, 2010).

Escalating resource use also imposes an increasing burden on the environment, through impacts related to resource extraction, use and disposal. Such impacts will increase if higher prices and growing concerns over scarcity induce countries to exploit sources such as tar sands that were previously deemed uneconomic.

Clearly, growing scarcity and rising prices also create strong incentives for private and public investment in research and innovation aimed at exploiting abundant or non-depletable resources, such as wind and solar energy. Governments can augment these incentives through ecological fiscal reform — increasing the tax burden on resource use and pollution.

Innovation can also alleviate resource demands by increasing efficiency or reducing waste, although such improvements can also make products cheaper, incentivising increased consumption. For these reasons, reducing resource demand often requires a mixture of technological improvements and policy measures addressing consumption.

Moreover, technological innovations can also augment pressures on the environment by increasing access to non-renewable or polluting resources. For example, new sources of fossil fuels could weaken the momentum behind global efforts to boost efficiency and mitigate climate change. In globalised markets, governments may have difficulty correcting market prices and pursuing ambitious greenhouse gas mitigation due to opposition from businesses and consumers. The result would be to delay the shift to cleaner alternatives and greatly increase harmful emissions.

Growing pressures on ecosystems

The demands of a growing global population with rapidly changing consumption patterns for food, mobility and energy are exerting ever-increasing pressure on the Earth's ecosystems and their life-supporting services. In combination with climate change, these changes also raise concerns about current meat-heavy diets and strategies for bioenergy production.

Exacerbated by climate change and continued pollution, rates of global habitat destruction and biodiversity loss are predicted to increase, including in Europe. The effects of continued ecosystem degradation on poverty and inequality in regions outside Europe may lead to increased immigration to Europe.

Drivers

Population, consumption, and economic growth

The past five decades have seen a rise in the global population to more than 7 billion people, and a concomitant industrialisation of agriculture (GMT 1) (UN, 2013b). About 2% of the global land area is currently covered by cities and infrastructures (UNEP, 2014). However, continued population growth and urbanisation (GMT 2) might cause this to double by 2050 (UNEP, 2014). In addition, continued global economic growth (GMT 5), accompanied by a rapidly growing global middle class — with resource-intensive, developed-world mobility and consumption patterns (GMT 2) — is likely to increase pressure on habitats and landscapes, particularly in regions with a high and direct dependence on natural resources for economic development, such as sub-Saharan Africa (OECD, 2012b).

Food and bioenergy

Dietary changes might override population growth as the major driver of global demand for land in the near future (Kastner et al., 2012). Meat-based food requires about five times as much land per unit of nutritional value as its plant-based equivalent (UNEP, 2009), and also has a higher water footprint which is, on average, 20 times higher for beef than for cereals (Mennonen and Hoekstra, 2010). Since the 1960s, global average meat consumption has almost doubled, from 23 kg per person to 42 kg, with the highest consumption in the US and Europe, while China and Brazil have recorded significant increases in the last 20–30 years (FAO, 2013a). Estimates suggest that global annual demand for meat products may increase by a further 76% relative to 2005 to 455 million tonnes in 2050 (FAO, 2012b).

A rapid expansion in land allocated to cultivating bioenergy crops (GMT 7) could have significant ecological impacts, such as deforestation, nitrogen pollution (GMT 10) and freshwater scarcity — the water footprint associated with bioenergy crops might increase ten-fold in the period 2005–2030 (Gerbens-Leenes et al., 2012). Mitigating associated pressures on ecosystems will depend on the development of bioenergy produced from agricultural and forestry residues that do not require additional land (UNEP, 2012a).

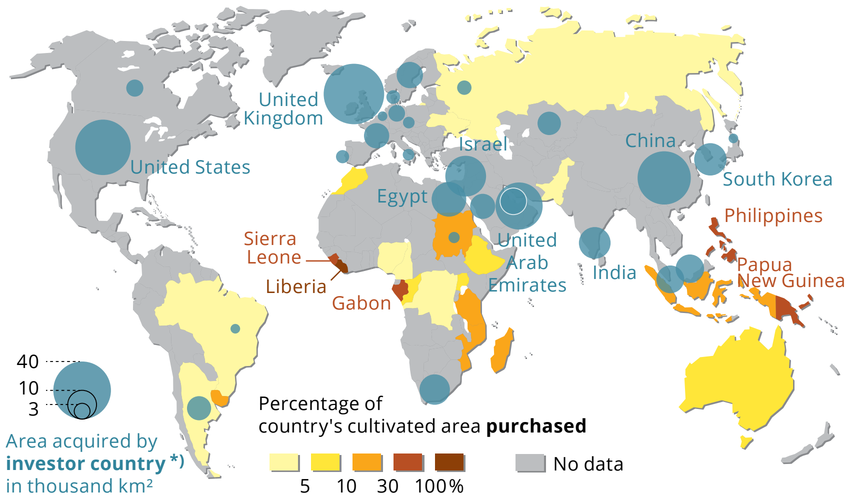
Increases in crop yields due to efficiency gains are unlikely to compensate for the growing demand for both plant- and animal-based food, and bioenergy. This could lead to a large-scale expansion of cropland, mostly at the expense of forest and grassland ecosystems, of 120–500 Mha (million hectares) by 2050 on top of the current 1 500 Mha of global cropland — 10% of the global land area. Furthermore, if loss of productive land to severe soil degradation and conversion to built-up areas is taken into account, cropland expansion could reach 850 Mha by 2050 (UNEP, 2014).

Competition for land and water

Growing global competition for productive land and freshwater resources is apparent in the recent rapid increase in large-scale transnational land acquisitions, mostly in developing countries (Map 8.1). Between 2005 and 2009, global land acquisitions by foreign investors totalled some 47 Mha (Rulli et al., 2013), slightly more than the area of Sweden. As a consequence, large-scale commercial farming is expanding at the expense of smallholder farmers and their access to land and water — in particular in Africa and parts of Asia.

Population growth, demand for food and climate change are expected to create significant threats to freshwater availability (Murray et al., 2012). Scenarios on global food demand for 2050 point to severe water stress in many regions, even if strong efficiency gains in its use are made (Pfister et al., 2011). This implies a threat to both human water security and to the functioning of ecosystems. Already today, around half of the world's major river basins, home to 2.7 billion people, face water scarcity in at least one month a year (Hoekstra et al., 2012), and water restrictions are projected to be further amplified by climate change (GMT 9).

Map 8.1 Transnational land acquisitions, 2005–2009



*) Acquired areas over one thousand km² only

Note: Transnational land acquisitions refer to the procedure of acquiring land (and freshwater) resources in foreign countries. It is often called 'land grabbing'. Most commonly, investors or investing countries are located in the developed world, while the 'grabbed' land is usually in developing countries. The term 'land grabbing' has been used by the critical press (e.g. The Economist, 2009) and non-governmental organisations for the recent unprecedented increases in transnational land acquisitions.

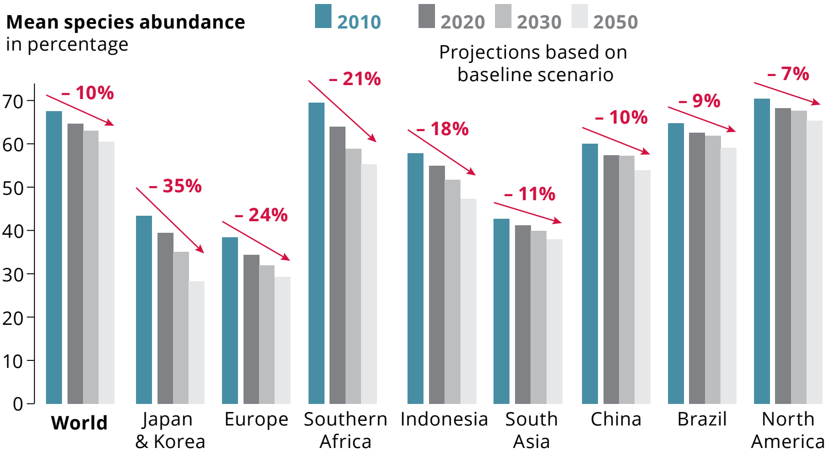
Source: Adapted from Rulli et al., 2013.

Trends

Terrestrial biodiversity

Some scenarios, including from the Organisation for Economic Co-operation and Development (OECD), consistently project a continued decrease of global biodiversity (Figure 8.1). Towards the mid-21st century, habitat loss due to bioenergy-crop farming and climate change is expected to gain in significance as drivers of decrease (CBD, 2010; OECD, 2012b). In a business-as-usual scenario for 2050, global terrestrial biodiversity measured as mean species abundance (MSA) is projected to decline further: from 68% of the level that potential natural vegetation could support in 2010 to around 60% in 2050. Strong losses may occur in, for example, in Japan/Korea, Europe, southern Africa, and Indonesia (Figure 8.1). These estimates may be conservative, as they exclude risks associated with transgressing possible ecosystem thresholds (Box 8.1) and the increasing spread of some invasive alien species because of climate change (Bellard et al., 2013).

Figure 8.1 Terrestrial mean species abundance, globally and for selected world regions, 2010–2050



Note: 'Mean species abundance' (MSA) is a measure of how close an ecosystem is to its natural state. It is defined as the mean abundance of original species in an area relative to the abundance in an undisturbed situation. A rating of 100% implies that the biodiversity matches that in the natural situation. An MSA of 0% means that there are no original species remaining in the ecosystem.

Europe refers to the EU-27 plus Iceland, Liechtenstein, Norway, and Switzerland; Southern Africa refers to Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe; South Asia refers to Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

Source: OECD, 2012.

Box 8.1 Thresholds and tipping points

There is evidence that ecosystems may need to maintain a minimum quality in order to function effectively. Below critical thresholds, ecosystems may suddenly switch in character, no longer providing the same kind, or level, of services (Barnosky et al., 2012). Thresholds, amplifying feedbacks and time-lag effects leading to tipping points make the impacts of global change on biodiversity hard to predict and difficult to control once they begin.

An area of particular concern in this regard is the Amazon basin, where recent research suggests that complex interactions between deforestation, fire and climate change could lead to a shift to savannah-like vegetation (Leadley et al., 2010). Global-scale impacts of such a shift would include a reduced carbon sink, increased carbon emissions, and the massive loss of biodiversity (Leadley et al., 2010). Some studies even suggest that a planetary-scale tipping point, implying radical changes in the global ecosystem as a whole, might be approaching (Barnosky et al., 2012).

Forests, drylands and wetlands

Demand for land has resulted in alarming tropical deforestation in recent decades. While overall global tropical deforestation remains high, some countries such as Brazil and Indonesia have slowed their rates. Mainly because of afforestation in temperate areas, some models project net global forest loss to halt after 2020 (OECD, 2012b). While plantations provide ecosystem services such as provisioning timber and carbon sequestration, they fall short of primary forests in delivering others, particularly forest biodiversity. Primary forests are projected to decrease steadily up to 2050, with the regions of most concern being Africa, Latin America and the Caribbean, and Southeast Asia (Miettinen et al., 2011; UNEP, 2012a).

Likewise, drylands and wetlands are threatened by depletion and loss of biodiversity. Drylands cover about 40% of the Earth's surface and host about 2 billion people, but their transformation into cultivated cropland continues at alarming rates, resulting in water stress and soil degradation. Very high rates of irreversible conversion of peatland and coastal wetlands such as mangroves for agriculture, forestry and infrastructure are also likely to continue (UNEP, 2012a).

Marine ecosystems

In recent decades global marine ecosystems and their biodiversity have become increasingly threatened. In 2011, around 29% of marine fish stocks were estimated as fished at a biologically unsustainable level and, therefore, overfished. In the same year, about 61% were fully exploited and only 10% held potential for increased harvesting (FAO, 2014). In addition to threats from overexploitation and nutrient pollution (GMT 10), ocean warming and acidification are projected to pose serious and increasing risks (GMT 9). Modelling of alternative marine fishery strategies up to 2050 indicates that marine catches and stocks will decline in the world's main fishing regions unless catches are reduced (Kram et al., 2012).

Implications

Loss of ecosystem services

Global and regional assessments indicate that biodiversity loss and ecosystem degradation will continue or accelerate under all policy scenarios considered (IEEP et al., 2009; Leadley et al., 2010). The drivers of biodiversity loss are likely to greatly outweigh the effects of any biodiversity protection measures (IEEP et al., 2009). Ecosystem degradation erodes nature's ability to support human societies (TEEB, 2010), as ecosystems provide a wide range of services (EEA, 2015a; MA, 2005) and indeed escalating competition for food, water and other natural resources could foster regional instability, increasing risks of conflict.

The benefits of protecting ecosystems and their associated services often far outweigh the costs (Balmford et al., 2002; TEEB, 2010). However, market systems seldom convey the full social and economic values of ecosystem services.

Reduced climate change mitigation potential and adaptive capacity

The carbon captured by natural ecosystems is of global importance in efforts to mitigate climate change (GMT 9). As global forest destruction currently contributes about 12% of global carbon dioxide emissions annually (van der Werf et al., 2009), the efficient protection of natural habitats could contribute substantially to continued carbon storage. In view of this, an international financial mechanism for reducing greenhouse gas emissions from deforestation and forest degradation, REDD+, has been adopted (UNFCCC, 2010).

Ecosystem-based approaches that rely on ecosystems to buffer human communities against the adverse impacts of climate change would allow natural ecosystems to play an important role in climate change adaptation (IPCC, 2014b; Jones et al., 2012; World Bank, 2010). Mangrove forests and coastal marshes, for example, can reduce disaster risks along exposed coastlines. And as the climate changes and temperatures increase (GMT 9) the need for ecosystem-based adaptation will increase (EC, 2013b).

Unequal distribution of impacts

The continued degradation of ecosystems and their services will create challenges, in particular for lower income groups in developing countries. It is estimated, for example, that non-market ecosystem goods and services account for 89% of the total income of the rural poor in Brazil, 75% in Indonesia and 47% in India. Sustainable management of ecosystems and socio-economic development are thus intertwined (Sachs et al., 2009; TEEB, 2010; UNDP, 2011).

For Europe, the effects of continued ecosystem degradation on poverty and inequality elsewhere in the world may lead to increased immigration to Europe. In addition, failing to take advantage of ecosystem-based solutions to tackle climate change in other parts of the world may increase costs in Europe. And crucially, transgressing critical ecological tipping points could cause unprecedented environmental, social and economic problems in Europe and elsewhere.

Increasingly severe consequences of climate change

Recent changes in the global climate are unprecedented over millennia and will continue. Climate change is expected to increasingly threaten natural ecosystems and their biodiversity, slow economic growth, erode global food security, threaten human health and increase inequality.

The risks of pervasive and irreversible impacts are expected to increase. They could, however, be reduced by further emissions abatement and adaptation measures, building on actions in Europe and internationally. Key risks for Europe include flood events, droughts and other weather extremes, threatening human well-being and infrastructure as well as ecosystems and biodiversity.

Drivers

Population, consumption, and economic growth

The evidence is clear. Climate change is real, and it is largely caused by human activities, primarily greenhouse gas emissions from fossil fuel burning, but also from other activities such as agriculture and deforestation. Through these activities, atmospheric concentrations of greenhouse gases such as carbon dioxide, methane or ozone have increased, causing the Earth to warm. Carbon dioxide concentrations have increased by about 40% since 1750, with most of the increase since the 1970s when global energy consumption started to increase strongly (IPCC, 2013b). Evidence from ice cores suggest that current carbon dioxide concentrations are higher than at any other time over the last 800 000 years (NAS and RS, 2014).

Recent progress in climate science allows for a clear attribution of the human contribution to changes in many components of the climate system (IPCC, 2013b). It is extremely likely ([8]) that most of the observed rise in global surface temperature since the mid-20th century was caused by increases in greenhouse gas emissions and other anthropogenic activities. It is also

([8]) In analogy with IPCC terminology, 'extremely likely' refers to 95–100% probability, 'very likely' refers to 90–100% likelihood, and 'likely' refers to 66–100% likelihood.

very likely that human influence has substantially contributed to increases in upper ocean temperatures, Arctic sea-ice loss, global mean sea-level rise and changes in the frequency and intensity of temperature extremes, such as heat waves, since the mid-20th century (IPCC, 2013b). There have been no significant long-term changes in the sun's energy output that could have contributed to the observed climatic changes (IPCC, 2013b).

Trends

Observed changes

The Earth's combined land and ocean surface temperature has warmed by 0.85 (0.65–1.06) °C between 1880 and 2012, and the number of hot days and nights ([9]) has increased over most land areas. Multiannual and decadal variability caused by natural factors does not contradict this long-term global warming trend. Observed warming is accompanied by significant reductions in ice and snow cover across the world — the minimum summer extent of Arctic sea ice has decreased by about 40% since 1979 (IPCC, 2013b).

Observed changes in precipitation show strong regional variations. In many regions, including Europe and North America, increases in either the frequency or intensity of heavy precipitation events have been observed. In contrast, climate records show an increased frequency and intensity of drought events in the Mediterranean and parts of Africa (IPCC, 2013b).

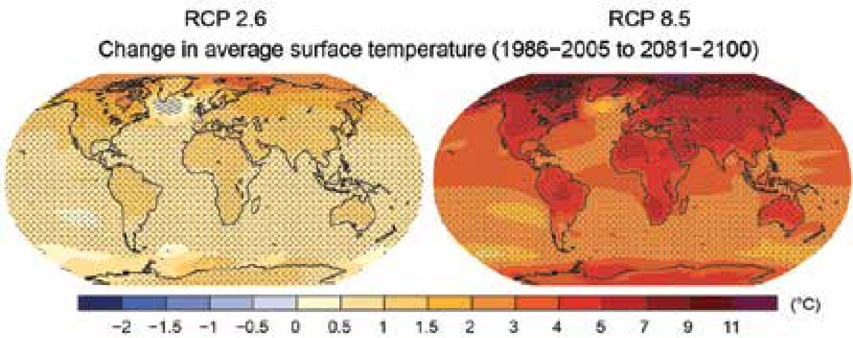
Global sea levels have risen by about 20 cm since 1901 due to thermal expansion and the melting of glaciers and ice sheets. The rate of increase has risen from 1.7 mm for 1901–2010 to 3.2 mm for 1993–2010 (IPCC, 2013b).

([9]) Hot days and hot nights occur when maximum and minimum temperatures, respectively, exceed the 90th percentile with respect to the 1961–1990 baseline climate.

Projected future changes ([10])

By the late 21st century (2081–2100), global mean surface temperature is expected to increase by another 2.6–4.8 °C compared to the reference period (1986–2005) if greenhouse gas emissions continue on a high trajectory (RCP 8.5; Figure 9.1, right). Strong emissions abatement could limit this to 0.3–1.7 °C (RCP 2.6; Figure 9.1, left). To have a two-thirds chance of keeping the global mean surface temperature rise to below 2 °C compared to the pre-industrial period, the target of the United Nations Framework Convention on Climate Change (UNFCCC), cumulative carbon emissions since 1870 need to be kept below 1 000 gigatonnes, of which 515 gigatonnes were already emitted between 1870 and 2011 (IPCC, 2013b).

Figure 9.1 Projected changes in average temperature, 2081–2100 relative to 1986–2005 for low-emission (left: RCP 2.6) and high-emission (right: RCP 8.5) scenarios



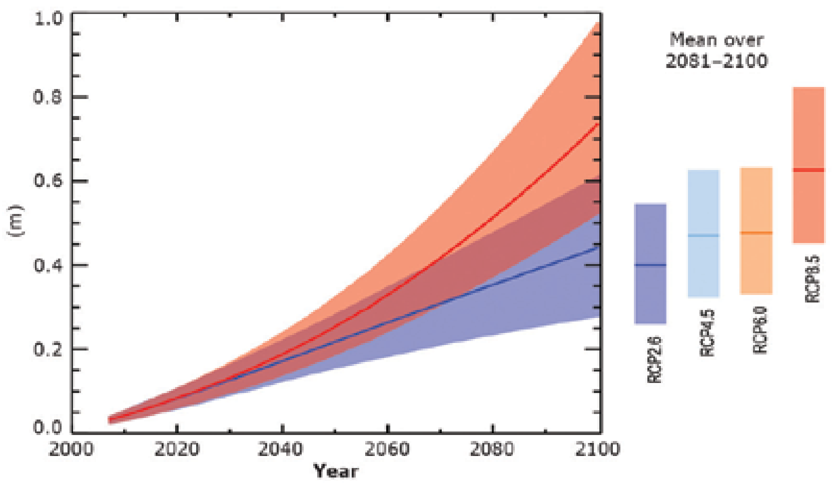
Source: IPCC, 2013b.

([10]) Projections of changes in the climate systems as given here utilise a new set of emissions scenarios, the representative concentration pathways (RCPs) (van Vuuren et al., 2011). These are four scenarios for levels of atmospheric greenhouse gases in the years up to 2100. They vary from a scenario in which greenhouse gas concentrations moderately increase between now and 2100 (RCP 2.6), to scenarios with greater levels of greenhouse gas concentrations (RCP 4.5 and RCP 6); all the way to a scenario in which greenhouse gas concentrations increase very greatly (RCP 8.5 — the scenario to which greenhouse gas emissions are currently heading if no further abatement measures are taken). The RCPs were developed to aid climate modelling, and underpinning the Fifth Assessment Report of the IPCC. A full description of the comprehensive set of multi-model estimates, as well as further details on the projected trajectories for the various climate components are found in the Fifth Assessment Report of the IPCC (IPCC, 2013a). While the focus of this report is on describing the potential situation by the end of the 21st century, projections for the coming decades and mid-21st century show similar spatial patterns (i.e. the same parts of the globe being affected by the same effects) but with smaller magnitude.

As temperature increases, it is very likely that the number and intensity of hot extremes and heat waves will increase globally. Projected changes in precipitation vary significantly between regions. Mean precipitation is likely to decrease further in such regions as the Mediterranean and North Africa, in particular under a high-emission scenario. In contrast, more intense and frequent extreme precipitation events are very likely in most mid-latitude regions, in, for example, Europe and North America, and wet tropical regions (IPCC, 2013b).

Global ocean temperature in the upper 100 m is projected to increase by 0.6–2.0 °C by 2100, depending on the emissions scenario. Arctic sea-ice cover will continue to shrink, and, under a high emissions scenario (RCP 8.5), the Arctic Ocean in September is likely to be almost ice-free before mid-century. Global mean sea-level rise is projected to accelerate further, with an additional rise by 2081–2100 of 0.26–0.55 m (RCP 2.6) or 0.52–0.98 m (RCP 8.5) (Figure 9.2). The rise will not stop in 2100, and even modest sustained warming of 2 °C above pre-industrial levels is estimated to lead to sea-level rise of at least 4 m over of the following 2 000 years (Foster and Rohling, 2013; Levermann et al., 2013).

Figure 9.2 Projected change of global mean sea level (21st century)



Note: The graph shows modelled global mean sea level rise over the 21st century relative to 1986–2005, derived from a combination of the CMIP5 ensemble with process-based models, for RCP 2.6 and RCP 8.5.

Source: IPCC, 2013b.

Implications [11]

Drawing on a larger scientific knowledge base than ever before, the IPCC has concluded that continued global warming will increase the likelihood of severe, pervasive and irreversible consequences in most world regions. However, risk reduction is possible through climate-change mitigation and adaptation (for details of the European context see www.eea.europa.eu/soer). Mitigation is the only option for reducing the risk of large-scale climate change. Action taken now and in the next few decades will determine the severity of consequences in the second half of the 21st century and beyond, while the co-benefits of mitigation action, such as reductions in air pollution, could be felt immediately.

Climate change mitigation and adaptation are also linked to other aspects of sustainable development, in particular the protection of biodiversity and food and energy security (GMT 8). A recent study, for example, suggests that with rising populations (GMT 1) and projected consumption levels (GMTs 2, 5 and 6), there will not be enough land to simultaneously conserve all remaining natural ecosystems, halt forest loss and switch to 100% renewable energy (Kraxner et al., 2013).

Natural ecosystems and their services

The IPCC estimates that an increase in global temperature of up to 2 °C compared to preindustrial levels carries moderate risks in terms of global aggregate impacts on ecosystems. Unique and threatened systems including the Arctic sea-ice ecosystem, coral reefs and the Amazon forest, however, are at very high risk of severe consequences even at this level of warming. Under scenarios of stronger warming, a large share of terrestrial and freshwater species is very likely to face an increased risk of extinction, with associated extensive further losses of biodiversity and ecosystem services.

Marine ecosystems such as coral reefs are projected to face substantial risks due to the combined effects of ocean warming, ocean acidification and local stressors — pollution and eutrophication (GMT 10) — in particular for

(11) Unless stated otherwise, the implications here are based on the findings of the Working Group II contribution to the Fifth Assessment Report of the IPCC (IPCC, 2014b).

medium- and high-emission scenarios. Moreover, a global redistribution of marine species is expected, with decreases in the catch potential of fisheries at tropical latitudes and associated implications for livelihoods.

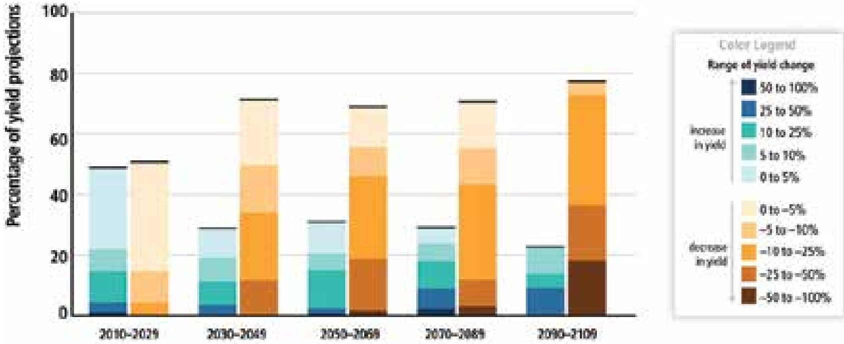
Human well-being and economic activities

Throughout the 21st century, climate change is projected to slow the rate of economic growth, increase inequality, erode food security and increase the displacement of people, particularly in low-income developing countries (GMT 1). Risks are unevenly distributed and are greater for disadvantaged people regardless of their country's level of development. With continued sea-level rise, low-lying areas, developing countries, in particular, are very likely to increasingly experience severe impacts through coastal flooding and coastal erosion. Indeed, flood losses in 136 major coastal cities around the globe could total USD 1 trillion or more annually by 2050 unless protection is upgraded (Hallegatte et al., 2013).

Estimated impacts of climate changes on crop yields since 1960 show some regionally limited gains but mostly losses. Projections suggest increasingly negative impacts on global agricultural production throughout this century (Figure 9.3). Global temperature increases of 4 °C or more towards the end of the 21st century, combined with increased food demand, would pose significant risks for global food security. Agricultural productivity is particularly threatened in semi-arid regions where most currently irrigated areas are projected to face increased water needs. Increases in carbon dioxide concentrations also impact plant growth directly — while elevated carbon dioxide levels can increase plant photosynthesis, they decrease food quality by inhibiting nitrogen uptake (Bloom et al., 2014).

Impacts from climate change-related extreme events are projected to increase further with warming. Increased urban flood damage from extreme precipitation is a key climate-related risk in most world regions, including in Europe. Increased drought stress and associated water restrictions and wildfires are expected in southern Europe, Australia, and parts of Africa, Asia and North America. In many of these regions, increased risks to drinking-water quality are projected even when conventional water treatment is applied.

Figure 9.3 Projected change in global aggregate crop yields due to climate change, 2010–2109



Note: Changes in crop yields are relative to late 20th century levels. The projections consider both low-emission and high-emission scenarios, tropical and temperate regions, and adaptation and no-adaptation cases. Data for each time frame sums up to 100%.

Source: IPCC, 2014.

Increases in human health impacts due to extreme heat events and the spread of disease are expected in many regions, including Europe (Bouzid et al., 2014; EEA, 2012a).

Increasing environmental pollution

Globally, levels of air pollution and releases of nutrients from agriculture and wastewater remain high, causing soil acidification, eutrophication of aquatic ecosystems and losses in agricultural yield. In the coming decades, overall pollution levels are projected to increase strongly, particularly in Asia.

Although the release of pollution may continue to improve in Europe, its ecosystems are likely to be affected by developments beyond the region's borders. Despite a fall in emissions, for example, there have not been equivalent reductions in air pollution partly as a result of the transboundary transport of pollutants.

Drivers

Since the start of the industrial revolution in the 19th century environmental pollution has grown into a global transboundary problem that affects air, water, soil and ecosystems, and is linked directly to human health and well-being (GMT 3). A key driver is the growth of the global population, from an estimated 1 billion in at the beginning of the 19th century to more than 7 billion today (GMT 1). This, combined with rapid, albeit uneven, economic development, has led to a massive increase in global production, consumption and mobility, together with increased demand for food and energy.

Pollution is linked to three main human activities: fossil-fuel combustion, primarily by industry and transport; the application of synthetic fertilisers and pesticides in agriculture; and the growing use and complexity of chemicals.

From 1990 to 2010, annual global emissions from fossil fuels rose by 50%, from around 6 billion tonnes to almost 9 billion tonnes (UNEP, 2012b). Fertiliser application per agricultural unit varies, but is particularly intense in China and increasing strongly in India. In contrast, it is declining slightly in Europe, though it remains above the global average (FAO, 2013a). In terms of chemicals, more than 100 000 substances are commercially available in Europe alone, and the number of new substances coming on to the global market is increasing rapidly ([12]).

([12]) Of particular concern are persistent, bio-accumulative and toxic substances that remain in the environment for a long time (UNEP, 2012b). However, due to space limitations chemicals are not further assessed here.

Trends

Air pollution [13]

Four main substances are cause for concern: nitrogen [14], sulphur, ozone [15] and particulate matter.

Atmospheric nitrogen pollution primarily consists of emissions of nitrogen oxides from industry and transport, and emissions of ammonia from agriculture (UNEP, 2012a). Global emissions of nitrogen oxides increased rapidly until around 1990, then fell significantly in Europe [16] but continued to grow in Asia. According to the representative concentration pathways (RCP) projections [17], emissions of nitrogen oxides are projected to continue to decrease in Europe up to 2050. In Asia, decreases may only start after another two or three decades of increase. Global ammonia emissions have followed a similar trajectory, but unlike nitrogen oxides, further increases are projected in most regions, with the possible exception of Europe (HTAP, 2010).

The formation of ozone is mainly driven by anthropogenic emissions of ozone precursors, such as methane and nitrogen oxides. Global modelling

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(13) For details of air pollution, agriculture and water see the SOER 2015 European briefings

(14) Nitrogen makes up almost 80% of the atmosphere in the form of nitrogen gases but can only be used by plants and animals if converted into another chemical form: reactive nitrogen. This process of nitrogen fixation occurs in three main ways: by lightning or high-temperature combustion (e.g. car exhausts and industrial combustion); by nitrogen-fixing plants (e.g. legumes); and by the industrial creation of synthetic nitrogen fertilisers. Reactive nitrogen is also released from animal manure.

(15) Ozone pollution as described throughout this publication refers to ozone concentrations at or near the Earth's surface (from the surface to 12–20 kms above it, referred to as tropospheric ozone), which can have adverse impacts for humans and the natural environment. The Earth's ozone layer is mainly found in the lower portion of the stratosphere, approximately 20–30 kms above Earth.

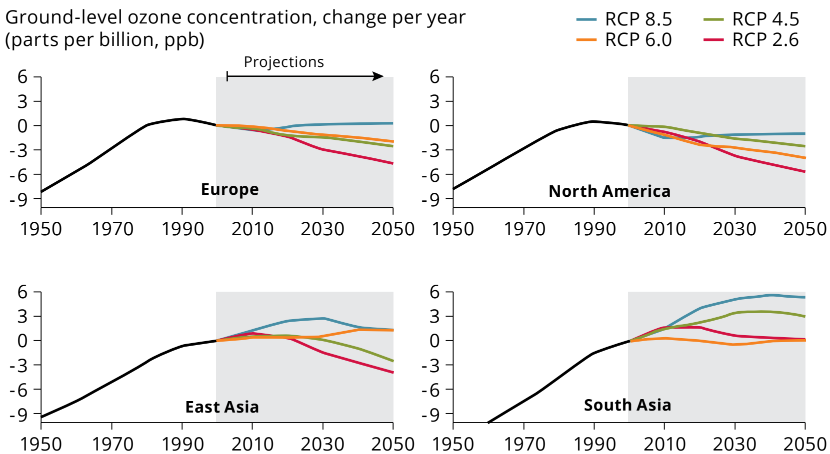
(16) This does not apply to emissions from international shipping. Nitrogen dioxide emissions from international shipping are estimated to have increased by around 25% for 2000–2007 only (IMO, 2009).

(17) Projections of changes in the climate systems as given here utilise a new set of emissions scenarios, the representative concentration pathways (RCPs) (van Vuuren et al., 2011). The RCPs are four scenarios for levels of atmospheric greenhouse gases in the years up to 2100. They vary from a scenario in which greenhouse gas concentrations increase moderately between now and 2100 (RCP 2.6), to scenarios with greater levels of greenhouse gas concentrations (RCPs 4.5 and 6); all the way to a scenario in which greenhouse gas concentrations increase very greatly (RCP 8.5 — the scenario toward which greenhouse gas emissions are currently heading if no further abatement measures are taken). The RCPs were developed to aid climate modelling and underpin the Fifth Assessment Report of the IPCC. They do not necessarily represent probable future socioeconomic pathways.

suggests that annual mean ozone concentrations in Europe increased until about 1990. Concentrations in East and South Asia have continuously risen since the 1950s and are projected to increase further or remain at high levels in the coming decades (Figure 10.1) depending on assumptions regarding global and regional emission pathways, as well as changes in the climate system (UNEP, 2012a).

Intercontinental transport of particulate matter and ozone is a growing concern (HTAP, 2010). Measurements in Europe and North America show that trans-oceanic air flows can lead to ozone concentrations that exceed air quality standards. Increasing emissions of methane and other precursors in other parts of the world might offset European emission-mitigation measures (HTAP, 2010) — despite substantial reductions of ozone-precursor gases in 2002–2011, measured ozone concentrations in Europe have only decreased marginally. Similarly, reductions in particulate emissions in

Figure 10.1 Historical and projected trends in ozone concentrations for Europe, North America, East and South Asia, 1950–2050



Note: The graphs show the results from a study that estimates regionally averaged changes in surface ozone due to past or future changes in anthropogenic precursor emissions based on 14 global chemistry transport models. Changes refer to ground-level ozone concentrations in 2000, expressed as parts per billion by volume (ppbv).

Source: Wild et al., 2012.

Europe have not led to proportional reductions in their concentrations (EEA, 2013a). These trends are at least partial evidence of the intercontinental transport of particulate matter and ozone-precursors.

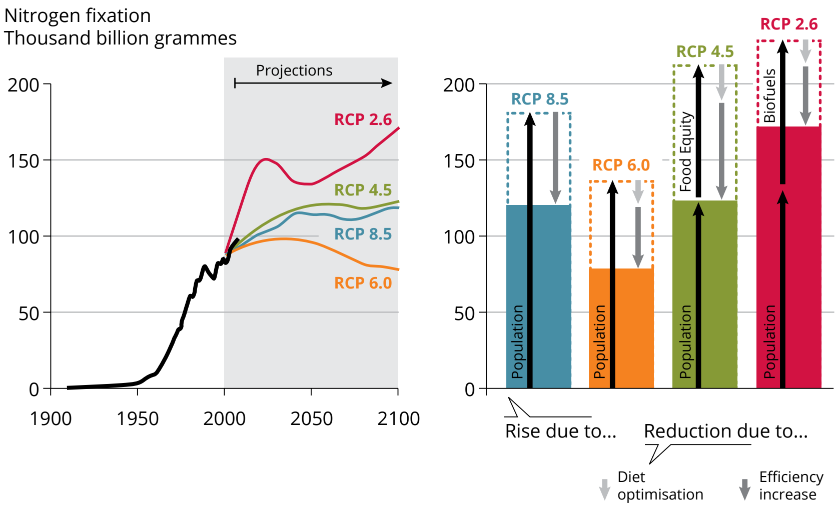
Releases of pollutants to aquatic systems and soils

In addition to deposits from the air, pollution of water, including groundwater, and soil results from diffuse agricultural or urban/industrial sources. One example is reactive nitrogen pollution of coastal ecosystems from agricultural fertiliser run-off into streams and rivers (OSPAR, 2010). At a global scale, increasing nitrogen and phosphorus pollution has become a major problem, as current levels may already exceed globally sustainable limits (Rockström et al., 2009).

Nutrient effluents from agriculture occur if synthetic fertiliser is applied inefficiently — in excess, at the wrong time, etc. Global fertiliser use is projected to increase markedly during the 21st century, from around 90 million tonnes in 2000 (Winiwarter et al., 2013) to potentially more than 150 million tonnes in 2050 (FAO, 2012b). Projections based on the RCP scenarios suggest that intensified biofuel production could also lead to high nitrogen fertiliser consumption (Figure 10.2). Thus, there could be trade-offs between greenhouse gas mitigation and pollution abatement.

Moreover, effluents from wastewater are projected to increase across the world, partly due to rapid urbanisation and the cost of adequate wastewater treatment systems. Globally, nitrogen and phosphorus effluents may increase by 180% and 150% respectively between 2000 and 2050, with, for example, the amount of phosphorus discharged annually into the Pacific Ocean possibly almost doubling between 2000 and 2050 (OECD, 2012b).

Figure 10.2 **Historical trend in global agricultural demand for industrial nitrogen fertiliser, 1910–2008; projections to 2100 based on RCP scenarios; and drivers of the projected changes in demand in 2100**



Note: Projections are based on the concepts of the RCPs (van Vuuren et al., 2011). Diet optimisation refers to a shift in consumption towards foods produced with more effective nitrogen uptake. Efficiency increase refers to the ratio of nutrients taken up by crops to the total amount of nutrients applied to soil.

Source: Winiwarter et al., 2013.

Implications

Biodiversity and ecosystem services

The acidification of freshwater ecosystems and soil in terrestrial ecosystems due to the deposition of airborne sulphur and nitrogen compounds poses a serious threat to global plant diversity (Azevedo et al., 2013) and the capacity of ecosystems to provide services (GMT 8). In such conditions, species well adapted to acidic environments are likely to thrive, displacing other plants and reducing diversity (Dise et al., 2011). An annual deposition of 5–10 kg of nitrogen per hectare has been estimated as a general threshold value for adverse effects on biodiversity (Bobbink et al., 2010). Acidic depositions in Europe have declined significantly since the 1980s (Vestreng et al., 2007).

However, Asian and African ecosystems may face increased risk of acidification in the coming 50 years, depending on the interplay of soil properties, individual site-management and regional and international policies. Areas at particular risk are South, Southeast and East Asia, where little of the emitted substances are neutralised by atmospheric alkaline desert dust (Hicks et al., 2008). At a global scale, 40% of protected areas currently designated under the Convention on Biological Diversity received annual nitrogen depositions exceeding the threshold of 10 kg per hectare in 2000 (Bleeker et al., 2011).

Ozone makes it harder for plants to photosynthesise, so high levels of ozone may also have significant effects on biodiversity and crops (Wedlich et al., 2012). This might, for example, take the form of changes in the species composition of semi-natural vegetation communities (Ashmore, 2005) or reductions in tree productivity (Karnosky et al., 2007). Some locations at high risk of ozone effects also face substantial risks from nitrogen deposition (Bobbink et al., 2010). Examples include the forests of Southeast Asia and southwest China.

The eutrophication of aquatic ecosystems is caused by high nutrient concentrations, in particular phosphates and nitrates. These have been linked to serious losses of aquatic life (Jenkins et al., 2013) and may cause hypoxia — aquatic ecosystems lacking sufficient oxygen to support most forms of life, producing dead zones (Rabalais et al., 2010). In the three years between 2008 and 2011 the number of eutrophication cases in marine ecosystems reported globally increased from around 400 to more than 750 ([18]). Dead zones are particularly common along the coasts of North America, East Asia and Europe (WRI, 2013). Indeed, the Baltic Sea has been characterised as the largest human-induced hypoxic area globally, with a ten-fold increase in hypoxia over the last 115 years, mainly due to effluents from agriculture (Carstensen et al., 2014).

Similarly, eutrophication of freshwater ecosystems — rivers and lakes — also remains a key challenge (UNEP, 2012a). Assuming that existing legislative frameworks remain unchanged, estimates suggest that the number of lakes with hypoxia may increase globally by 20% by 2050 (OECD, 2012b).

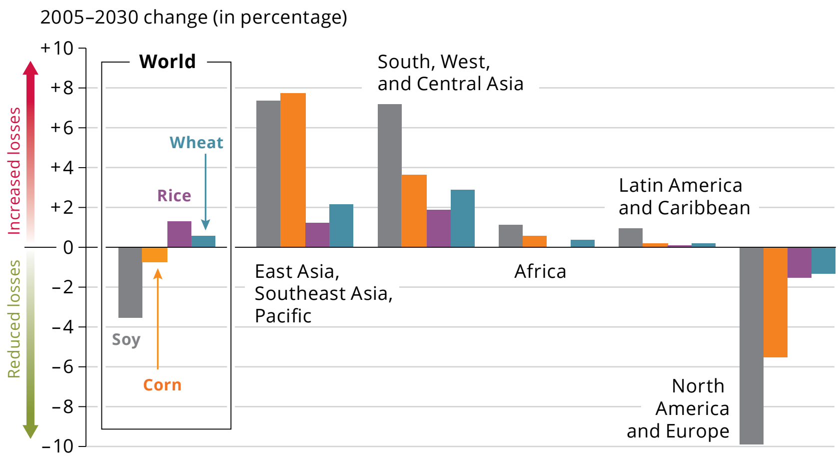
([18]) Other aspects of marine pollution, such as litter (both micro particles and larger materials, e.g. plastics) are not assessed here due to space limitations.

Agriculture and food provision

Global agricultural production is affected by high concentrations of ozone, as well as by other threats including climate change (GMT 9). In rural areas, elevated ozone levels tend to last longer and potentially cause a wide variety of damage to various ecosystems, notably decreasing crop yields.

Global estimates suggest that the range of current relative yield losses (RYL) are 7–12% for wheat, 6–16% for soybeans, 3–4% for rice, and 3–5% for maize (van Dingenen et al., 2009). Highly productive agricultural areas, such as parts of Europe, India, and the mid-west United States, are particularly affected by substantial production losses due to ozone. Assuming that current legislation remains unchanged, yield losses are projected to increase, especially in Asia, and particularly of soybeans and maize. In Europe and North America yield loss is projected to fall (Figure 10.3).

Figure 10.3 Projected differences in relative yield losses for wheat, rice, maize and soy beans due to high ozone concentrations, major world regions, 2005–2030



Note: The 2030 scenario assumes the implementation of current legislation for the major world regions. Positive relative yield loss values signify increased yield losses in 2030 compared with 2005.

Source: NEP and WMO, 2011.


North
Atlantic
Ocean
South
Atlantic
Ocean

Diversifying approaches to governance

In the context of globalisation, governments are struggling with a mismatch between the increasingly long-term, systemic challenges facing society and their more limited focus and powers.

The need for coordinated action at the global scale is reflected in the proliferation of international agreements, and the increasing role of business and civil society in governance. This diversification of governance approaches is necessary. But it raises concerns about coordination and effectiveness, and the replacement of government authority with less accountable or transparent non-state actors.

Drivers

The socio-economic progress of recent centuries has been accompanied by a steady evolution in systems of governance, i.e. the mechanisms used to steer society away from collectively undesirable outcomes and towards socially desirable ones (Young, 1999). In particular, the creation of complex state hierarchies and systems of commerce has played a key role in incentivising and enabling economic development, and in managing associated social and environmental harm. In more recent times, however, challenges and opportunities are driving the emergence of new approaches to complement hierarchical and market-based governance.

New challenges for established governance approaches

One factor creating demand for new governance approaches is the mismatch of scale between the increasingly long-term, systemic challenges facing society and the more limited focus and powers of governments (Held, 2006). For example, integration of global markets means that many effects of resource use are felt far from where products are consumed (GMT 6). As a result, governments may have little awareness of the impacts of domestic consumption, and little ability to influence them because of the territorial limits on state authority. Additionally, global trade agreements constrain states from differentiating between imports based on production methods (WTO, 2014b).

Other challenges relate to the management of global natural capital. Greenhouse gas emissions, for example, affect the atmosphere as a whole, with related impacts likely to fall most heavily on future generations. Since mitigating climate change requires coordinated action worldwide, individual governments may have little motivation to take unilateral steps to reduce emissions.

Similarly, individual countries may lack incentives to protect global public goods such as rainforests because the benefits that they provide, such as storing carbon and hosting biodiversity, are very widely distributed and long term compared to the short-term financial gains that other land uses could generate. In each of these instances, the failure of market prices to internalise all the costs of resource use and pollution mean that market forces are unlikely, in themselves, to produce sustainable and socially beneficial outcomes.

Political cycles can also reinforce the human tendency to disregard the long term when making choices (Ainslie, 1992). Electorates often prioritise immediate concerns such as jobs and crime, while politicians tend to focus on the next election (Meadowcroft, 2002). The result is short-termism in policymaking, deterring action that delivers benefits in the future and encouraging ones that result in delayed costs.

Governance failures can also undermine national policy responses. For example, government institutions can be inflexible and slow-moving when confronting such complex challenges as climate change (Young, 2009). The content of policy is also susceptible to bias resulting from collective action by well-resourced interest groups (Olson, 1965) or corruption.

Changing technologies and values

Social and technological changes (GMT 4) are also facilitating innovations in governance. Information and communication technologies have created new ways to establish international communities and networks, encouraging collaboration and information sharing. Such advances are key to the increased involvement of non-state actors in global environmental governance.

Enormous increases in data accessibility and storage are also closely linked to changing expectations and values. Citizens increasingly demand transparency and accountability from governments and business. Media coverage of the social and environmental harm associated with globalised supply chains has grown. And recent decades have witnessed a shift in attitudes towards humanity's relationship with nature, and the responsibility owed to vulnerable populations and future generations (WBGU, 2011).

Trends

While governments are likely to remain the primary mechanism for coordinating human activity, more diverse governance approaches are emerging. Some can be seen as extensions of state authority, while others involve non-state and local actors in 'network governance', based on informal institutions and instruments (Meuleman, 2014).

Intergovernmental collaboration

International environmental agreements have proliferated in recent decades, with activity peaking during the 1990s when more than 350 environmental agreements were adopted or amended (Mitchell, 2014). The subsequent decline in new agreements reflects both the increasingly dense network of regimes in place and growing awareness of their limitations. Negotiations are often extremely complex and slow, and the policymakers involved may have strong incentives to defer costly actions that promise only distant benefits. A lack of enforcement mechanisms further undermines their effectiveness and many international agreements are yet to be implemented (KPMG, 2012).

One approach that has emerged to facilitate intergovernmental collaboration is the establishment of long-term targets. For example, many countries have adopted greenhouse gas emissions-reduction targets stretching to 2050 (Climate Interactive, 2014). By signalling long-term ambitions, such targets potentially provide a way to secure reciprocal commitments from other states, as well as helping to deter government short-termism by locking domestic policy into a long-term framework.

International policymaking is also taking place in supranational blocs, with the EU providing by far the most advanced example. Partial pooling of state sovereignty and the establishment of effective enforcement mechanisms has enabled the EU to agree and implement some of the world's highest environmental standards. Despite the failings of global climate change negotiations, the EU and Member State governments have delivered significant reductions in greenhouse gas emissions (EEA, 2014c), in the knowledge that their major trading partners are making similar commitments.

In contrast, the emergence of global supranational hierarchies is much less advanced. As a result, 'Intergovernmental organisations are inadequately resourced, are not vested with the requisite authority, lack competence and coordination, and display incoherence in their policies and philosophies' (UNEP, 2012a).

Non-state actors and hybrid approaches

The limitations of state and intergovernmental mechanisms in addressing global governance challenges have enabled non-state actors to assume an increasing role. Civil society and business complement the state's rule-making and enforcement powers in their ability to operate informally across borders, and their substantial local knowledge and contacts (Evans, 2012).

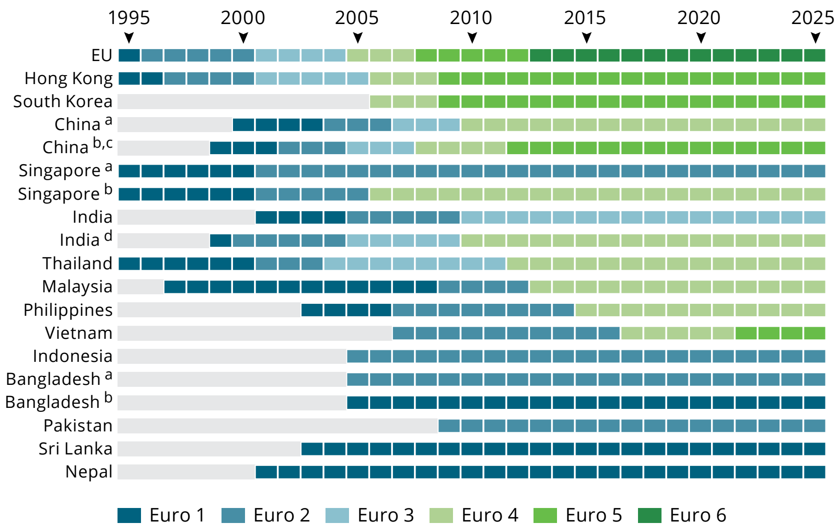
The growing importance of network governance can be partially explained by changes in the scale and focus of non-governmental organisations (NGOs). The number of international NGOs has increased from less than 5 000 in 1985 to more than 50 000 today (UIA, 2014). At the same time, their goals have shifted from primarily aiming to steer government and intergovernmental processes, to creating norms and standards, and monitoring and enforcement processes (Cole, 2011).

Business becomes involved in governance processes in response to pressure from customers, investors and the public, as well as to manage environmental impacts on their operations and pre-empt or influence governmental action (Lyon, 2006). Crucially, business often has a commercial interest in adopting production standards. Network governance approaches can thereby operate by aligning the interests of different stakeholders — with NGOs proposing standards and business promoting them (Cashore and Stone, 2012).

Certification and labelling schemes, for example, enable firms to signal good practice to consumers and differentiate their products from those of competitors. Such approaches today address some key environmental problems, such as forest degradation, ecosystem fragmentation and pollution (Ecolabel Index, 2014).

In other situations, companies may favour the harmonisation of standards to reduce production costs or achieve level playing fields with competitors. In such cases, business may have a strong incentive to lobby governments to formalise and enforce standards. The adoption of EU emissions

Figure 11.1 Adoption of the EU's Euro emission standards for cars and vans in Asian countries, 1995–2025



a. Petrol
b. Diesel
c. Beijing: Euro 1 (January 1999); Euro 2 (August 2002); Euro 3 (2005); Euro 4 (1 March 2008); Euro 5 (2012). Shanghai: Euro 1 (2000); Euro 2 (March 2003); Euro 3 (2007); Euro 4 (2010); Euro 5 (2012). Guangzhou: Euro 1 (January 2000); Euro 2 (July 2004); Euro 3 (September–October 2006); Euro 4 (2010).
d. Delhi, Mumbai, Kolkata, Chennai, Hyderabad, Bangalore, Lucknow, Kanpur, Agra, Surat, Ahmedabad, Pune and Sholapur.

Source: CAI, 2011.

standards for road vehicles across Asia (Figure 11.1) illustrates both the desire for standardisation in global production, and the interplay of state and non-state actors in environmental governance.

The rise of networks is also providing opportunities for state actors at the local level. Cities and networks of cities, for example, are expected to play an increasingly important role in environmental governance (NIC, 2012). Cities concentrate populations, economic activity and innovation of all sorts. This not only creates opportunities for resource-efficient ways of living but also means that changes at local scales can have far-reaching effects. Better networking of cities, as illustrated by the Covenant of Mayors (CM, 2014), therefore has a crucial role to play in the diffusion and up-scaling of local innovations.

Implications

The growing scale and complexity of humanity's interactions and environmental impacts suggest that the new governance models outlined are both necessary and desirable. It is clear, however, that they bring a variety of uncertainties and risks.

First, the dispersion of authority to numerous actors pursuing varied interests is already producing a profound shortage of coordination in governance. The work of many non-state actors is sector specific, which increases the risk that links between different policy areas will be missed (Grevi et al., 2013). Worse than a lack of coordination is direct competition between actors, which can result in inaction, wasteful use of funding and complications in national and international policymaking. For the EU, as for other stakeholders, progress in environmental governance will therefore mean striking the right balance between inclusiveness and effectiveness (Grevi et al., 2013).

The increasing number and diversity of actors involved in global governance could also mean that stakeholders are confronted with an ever increasing array of legislation, standards, norms and labels. The Ecolabel Index currently tracks 459 schemes covering 197 countries (Ecolabel Index, 2014). While these have an important role to play in environmental governance, a plethora leads to confusion and loss of trust (EC, 2013d).

Second, the rise of business and civil society in governance can have a mixed impact on democratic processes. At one level, it enables a larger number of stakeholders to shape governance approaches, affording a greater voice to grassroots organisations with a keen appreciation of local realities. At the same time, however, the growing role of non-state actors could well undermine the authority of elected governments, potentially threatening democratic processes.

While changing technologies and rules on access to information mean that government choices are increasingly subject to the scrutiny of empowered and interconnected citizens, a shift to non-state governance may reduce the democratic legitimacy, transparency and accountability of decision-making.

In elected parliamentary systems, decision-making processes and debates take place in the public domain, and the representatives involved are accountable to voters. In contrast, non-state actors are unelected and unaccountable, with their workings not always transparent. The funding and expenditure of non-state actors, for example, cannot necessarily be traced by members of the public and debates on policy and strategy tend to occur behind closed doors. This is a particular challenge where civil society engagement takes the form of short-term coalitions directed at specific issues — a process termed 'bazaar governance' (Demil and Lecocq, 2006). As non-state actors become more important in global governance, they will need to improve their transparency and accountability.

The extent to which the environment is already regulated means that the focus of governance has increasingly turned to how to make existing standards and norms work better. Experience suggests a need for flexibility and the right mix of hierarchical, market-based and network approaches. Risk assessment that addresses the state of the environment, pressures and conduct is likely to point to the need for a range of responses. Openness to different and evolving governance approaches is therefore highly desirable.

Authors and acknowledgements

EEA lead authors

Anita Pirc Velkavrh, Mike Asquith, Teresa Ribeiro, Tobias Lung.

EEA contributors to SOER 2015 global megatrend briefings

Anca-Diana Barbu, André Jol, Andrus Meiner, Anke Lükewille, David Stanners, Dorota Jarosinska, Frank Wugt Larsen, Gorm Dige, Hans-Martin Füssel, Jock Martin, John van Aardenne, Marie Cugny-Seguin, Martin Adams, Paul McAleavey, Ronan Uhel, Stefan Speck, Thomas Henrichs, Valentin Voltescu.

Advisory group

Annika Hedberg, European Policy Centre (EPC);
Jacob Werksman, DG Climate Action;
Jan Bakkes, Netherlands Environmental Assessment Agency (PBL);
Laurant Bontoux, JRC Brussels;
Louis Meuleman, DG Environment;
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European Environment Agency
Kongens Nytorv 6
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