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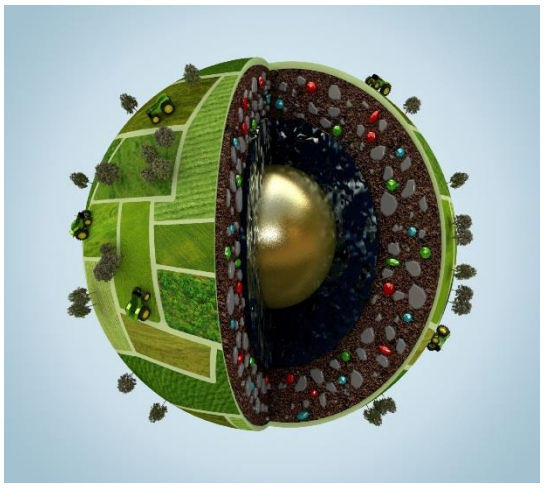
Trends in the Environment



Human activities interact with natural systems in complex ways; they can cause long-term damage to systems humans are dependent on. This POSTnote summarises a range of such pressures on the environment. It also identifies a number of trends and their effects on the UK.

Overview

- Human activities have altered natural processes on a planetary scale, which may affect the wellbeing of future generations.[1]
- The main pressures on the environment are activities that emit wastes or prioritise the short-term use of natural resources over the long-term consequences.
- There have been some environmental improvements in developed countries, but negative global trends persist in the atmospheric, aquatic and terrestrial environments.
- There are policy options that could protect the environment while meeting human needs. They require more efficient use of resources and mitigation of drivers of environmental change, such as pollution.

Environmental Change

Over the last 100 years, the global population quadrupled to 7bn and GDP increased about 20-fold.[2] The resulting scale and intensity of pressures on the environment altered nearly all the Earth's systems,[3] leading to proposals that the planet has entered a new geological era: 'the anthropocene'.[4]

Humans use the environment as both a source of raw materials and as a sink for wastes. Both these activities cause environmental change, which has led some researchers to try to define global boundaries beyond which further change poses a risk to human wellbeing, known as the 'safe operating space' (POSTnote 421). It sets limits for nine areas of concern: climate change, ocean acidification, stratospheric ozone, flows of nitrogen and phosphorus, aerosols of pollutants in the atmosphere, levels of freshwater use, land use change (such as deforestation), loss of biodiversity and the prevalence of novel pollutants (such as pesticides).[5] Given the complexity of defining global boundaries it has been questioned whether the approach is useful for informing policy.[6,7] Recent research has shown that defining boundaries for environmental change at regional scales may be more useful.[8] This POSTnote summarises a number of drivers of environmental change and some related national and international trends in atmospheric, aquatic and terrestrial environments.

Pressures Driving Environmental Change

For much of Europe, including the UK, there have been some improvements in local environments in recent decades. In contrast, at a global and regional level detrimental changes in the environment continue to be driven by a number of interacting pressures, including:

- **Demographic change**. By 2020, the global population is predicted to rise from 7.2 to 7.7 billon; projections to 2050 are less certain (POSTnote 438), ranging from 8.3 to 10.9 billon. Most population growth will be in the least developed countries, but the UK's population is projected to rise from 65 to 67 million by 2020 and over 73 million by 2037. This will create additional demand for housing, water, food, energy and transport.
- **Urbanisation**. In 2013, more than 53% of the global population was urban,[9] with 20 cities of more than 10 million people. Cities account for around three quarters of the world's resource consumption, disproportionately driving global changes in land use through demand for food, water and energy.[10] Urban growth rates are highest in Africa and Asia. The UK's 53 million urban population is projected to rise to over 58 million by 2037.
- **Economic growth**. Recent economic growth has improved human wellbeing, but the planet's stocks of renewable and non-renewable resources (such as soils and fossil fuels) have declined. The elements of the natural environment that provide valuable goods and

services to people are referred to as renewable and non-renewable natural capital.[11]

- **Transformation of renewable natural capital.** Over the last 60 years, human activities, such as draining of wetlands or deforestation to provide land for agriculture, have transformed renewable natural capital at an increasing rate.[12] The Office for National Statistics has estimated the partial value of benefits from UK renewable natural capital over 25 years at £1.6 trillion (a full estimate will require new valuation approaches).[13] However, the 2011 UK National Ecosystem Assessment (NEA) stated that loss and alteration of natural habitats over the last 50 years has reduced by 30% the provision of ecosystem services (the benefits humans obtain from an ecosystem like food production).[14]
- **Levels of resource use**. In 2010, nearly 72bn tonnes of raw materials (including construction materials, fossil fuels and biomass) were extracted globally, which is projected to increase to 100bn tonnes by 2030.[15] The entire life cycle of resource use, from extraction and production through to use and disposal can produce undesirable emissions and waste (Box 1).
- **Increasing rate of technological change**. Technology can reduce resource use and environmental pollution, but can also introduce novel pollutants into the environment that pose risks. Relevant technologies include ICT (POSTnote 510), robotics,[16] nanotechnology[2] and synthetic biology (POSTnote 497).
- **Levels of environmental pollutants**. Pollutants are projected to increase globally in air, freshwaters, marine waters and soil, particularly in Asia.[2] There have been reductions in some 'legacy' pollutants in line with the requirements of international agreements, such as the Stockholm Convention on Persistent Organic Pollutants.[17] However, other pollutants are of continuing or emerging concern. For example, rates of endocrine diseases and disorders have increased, such as hypothyroidism, but establishing whether endocrine disrupting chemicals in the environment are affecting hormonal systems remains an area of controversy.[18,19]
- **Climate Change**. By the 2080s, if carbon emissions continue to rise unabated, average global temperature is likely to have increased by 2.6-4.8°C above levels recorded at the end of the 20th century.[20] Effects are likely to include global sea level rise, a reduction of glaciers, ice sheets and sea ice, melting of Arctic permafrost (POSTnote 454) and an increasing frequency of extreme weather events.[21] Impacts on the UK may include higher average temperatures, changing rainfall patterns and more frequent extreme events such as drought, floods and heatwaves.[22]
- **Biodiversity Loss.** Biodiversity is a term used to describe the variety of life on Earth.[23] Loss of biodiversity has an effect equal to or greater than most other environmental pressures.[24] However, the ecosystem effects of biodiversity declines are complex to assess (Box 2).[25] Existing assessments of biodiversity loss are based on species' extinction rate and abundance, particularly terrestrial vertebrates, but these do not provide sufficient information to determine long-term effects on ecosystem services (Box 2).[26] While the relationship between biodiversity and ecosystem service provision is generally positive,[32] it can be uncertain. For example, a greater number of plant species in a grassland produces higher levels of forage for livestock, but it is less clear if it contains the optimal nutrients.[33]

Box 1. Changing Municipal Waste Trends

The quantity of municipal waste generated in OECD countries has risen steeply since 1980, exceeding an estimated 650 million tonnes in 2010 (540 kg per person).[27] However, in the EU-28 municipal waste declined by 4% between 2004 and 2012, falling to 481 kg per person.[28] This was in line with multiple waste targets set out by the EU, such as those in the EU Waste Framework Directive that require 50% of household waste to be recycled or prepared for re-use by 2020. The Environmental Audit Select Committee recently noted that household recycling rates in England have plateaued (44.8% in 2014); but data on commercial and industrial recycling rates are unreliable.[29] Wales achieved a recycling rate of 56.2% in 2014/15 after the introduction of mandatory food waste collection. There is wide variation in rates between local authorities in England, Scotland and Northern Ireland.[30]

Increasing rates of technological change may create challenges for recycling (POSTnote 425); for example, many products are using increasingly complex combinations of materials; such as computer chips, which contain more than 60 elements.[31] However, technology could also facilitate product recovery, such as using radio frequency identification (RFID) tags to track products at the end of life.

Atmospheric Environment

Internationally-agreed targets have led to controls on some atmospheric emissions, such as ozone depleting chemicals,[34] but other air pollutants continue to pose health and environmental challenges (Box 3). Substances of concern include fine particulates, nitrogen oxides and ozone but separating out the health effects of different air pollutants is difficult (POSTnote 458). In 2010, almost 84% of the world population lived in areas with concentrations

Box 2. Assessing the Ecosystem Effects of Biodiversity Loss

Evidence suggests that 322 vertebrate species (including marine species) became extinct since 1500.[35] The 2014 Living Planet Index, which tracks changes in 10,380 populations of over 3,000 vertebrate species, showed a decrease in population size of 52% between 1970 and 2010.[36] However, vertebrates constitute less than 2% of all described species. Less information is available for invertebrate species, but 67% of monitored populations are declining.[37] In the UK, 60% of all species for which quantitative information is available have declined over the last 50 years, but data is available for only 5% of the roughly 59,000 terrestrial and freshwater species in the UK,[38] and for very few of the 8,500 multi-cellular marine species.[39]

Developing metrics to assess how this loss affects the integrity of ecosystems at relevant scales[25] would require measures of the composition of ecological communities including species abundance, diversity, distribution and functional diversity (the diversity of organisms' characteristics linked to their roles in ecosystems, like being a pollinator).[25] Evidence shows that species richness (the number of species represented in an area) is important for ecosystem functioning.[24] For example, reductions in soil biodiversity reduce nitrogen cycling in leaf litter,[40] affecting ecosystem services, such as timber production. Ecosystem functioning is likely to depend upon local biodiversity, which declined on average by 13.6% globally (27% in the UK) between 1500 and 2005 because of land use change (from natural habitats to agriculture).[26] A recent assessment of 4,424 species that contribute to some ecosystem functions in Great Britain also showed declines over four decades.[41] Long term consequences of such declines for ecosystems may also include decreased resistance to shocks, such as droughts.[42]

of fine particulates above the World Health Organization's air quality guideline.[9] Despite improvements in UK air quality over recent decades, estimates of the mortality burden from long term exposure to fine particulates (expressed as the percentage of annual deaths from all causes in those aged 30+[43]) range from 2.5% in rural areas to 8.8% in the most polluted London boroughs.[44] Road transport is responsible for over 50% of air pollutants such as particulate matter and nitrogen dioxide in urban areas (POSTnote 496).[45] London and several other UK cities failed to meet EU Air Quality Directive limits for nitrogen dioxide by 2015 and Defra has submitted new air quality plans to the EC.[46]

Greenhouse Gases

Concentrations of carbon dioxide, methane and nitrous oxide are at levels unprecedented in the atmosphere over the last 800,000 years. In 2014, global average atmospheric concentrations of carbon dioxide reached 397.7 parts per million (ppm) and the average annual rate of increase was 2.06 ppm over the last decade (Figure 1).[47] About half of the carbon dioxide emitted by human activities between 1750 and 2011 occurred in the last 40 years. However, European greenhouse gas (GHG) emissions decreased by 19% since 1990.[11] UK GHG emissions are now 36% below 1990 levels,[48] which exceeded the second UK 2013-17 carbon budget of a 29% reduction requirement (POSTnote 503).

Aquatic Environment

Freshwater and marine systems are connected parts of the water environment, and play a major role in planetary processes such as global climate and weather patterns.[49] Oceans account for over 97% of water on the planet (and cover more than 70% of its surface), 2% is glaciers and ice caps, with less than 1% as ground and surface freshwaters.

Freshwater Systems

Pressures on freshwater systems range from the global to the local. Climate change increases the frequency and intensity of droughts, decreasing water availability in some areas and increasing it (flooding) in others. The quality of freshwaters is also declining because of excess nutrients, including nitrogen, phosphorus and eroded topsoil sediment, fuelling abnormally high and damaging growth rates in microorganisms and plants (eutrophication, POSTnotes 477 and 478). At its worst, oxygen becomes depleted in freshwater bodies, estuaries and coastal areas to levels that cannot support aquatic life. Global river export of nutrients has increased by approximately 15% since 1970.[50]

The condition of local freshwater and wetland habitats is affected by the extent to which water is extracted, diverted, contained and contaminated by activities in the area of land that they drain (their 'catchment'). Over-extraction has affected the surface water flows of freshwater bodies, changing their ecology. Global freshwater withdrawals increased nearly seven times in the last century.[51] Agriculture is the largest user of freshwater globally,[52] followed by industry and households. Nearly 80% of the global population is exposed to water security risks;[53] developed countries have built water infrastructure to manage water stresses, but more than 1.2 billion people are in areas of physical water scarcity in developing countries.[54]

Box 3. Environmental Effects of Air Pollutants

Air pollutants that have direct environmental effects include sulphur (as sulphates), nitrogen (as nitrate, ammonia and nitric acid) and ozone (POSTnote 458). Deposition of sulphur and nitrogen from air to the ground can affect vegetation and habitats by acidifying soils and freshwater systems. The proportion of UK habitats that are overly acidified is expected to decline from 54% in 2006-08 to 40% in 2020.[55] Nitrogen deposition also leads to the deterioration of habitats and loss of biodiversity because of excessive nutrients (eutrophication). The proportion of UK habitats exposed to excessive levels of nutrients is expected to decline from 58% in 2006-08 to 48% in 2020.[55] Recovery from damage from both has been slower than expected,[55] but recent research suggests that management of vegetation can enhance recovery from nitrogen deposition.[56] Elevated concentrations of ground level ozone affects the ability of plants to photosynthesise, reducing crop yields, forest growth and the composition of natural plant communities. In the northern hemisphere, mean background ozone levels range from 35 to 40 parts per billion (ppb), compared to pre-industrial levels of about 10-15 ppb, and are increasing by 0.2 ppb per year.[57]

Approximately 45,000 large dams along with smaller dams, in-channel modifications, levees and artificial channels have altered flows, effecting the ecology of surface waters.[58] Reduced connectivity between the land and the freshwater bodies that drain and flood it also has ecological effects, such as changes in the transfer of nutrients from rivers to floodplains. Other stressors on freshwater ecology include the introduction of hundreds of invasive non-native species,[59] as well as pollutants ranging from pathogens and heavy metals to synthetic chemicals and pharmaceutical residues.[60] In response to EU legislative requirements (Box 4) there have been improvements in water quality across Europe,[11] but pollution challenges remain including excess nutrients and organic chemicals, such as pesticides.[61]

Oceans

The oceans have absorbed about 30% of the CO_2 emitted by human activities. This has caused global surface ocean pH to decline (acidification) from 8.2 to 8.1 and may decline to 7.8 by 2100 (pH values measure acidity or alkalinity; lower than 7 is acidic).[62] Marine organisms with calcium-rich shells or skeletons will be affected, including key organisms that underpin the biological productivity of the oceans, such as phytoplankton.[62] Other stressors include invasive non-native species,[63] nutrient pollution, deoxygenation, increasing sea surface temperatures[64] and widespread persistent chemical pollutants, such as mercury.[65] These pollutants either dissolve in water, are stored in sediments or accumulate in organisms.[66] Oceans have also become a sink for increasing amounts of litter, such as plastics, with at least 5.25 trillion pieces of plastic weighing 268,940 tonnes floating in the ocean.[67] It has been estimated that of the 275

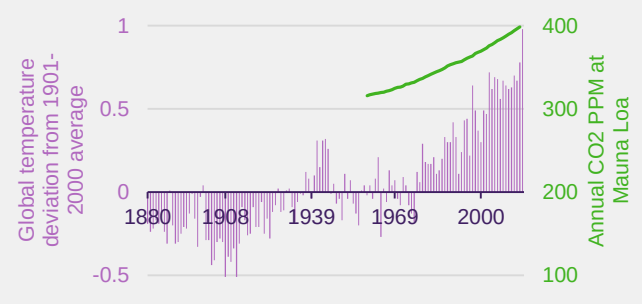


Figure 1. Atmospheric Concentration of CO_2[47] and Global Temperature[68]

Box 4. Water Framework Directive Requirements
The EU Water Framework Directive requires that all water bodies in the EU attain 'good' or 'high' status in ecological, chemical and hydrological quality criteria (POSTnote 478, Library Briefing 7246). Approximately 78% of England's surface water bodies are expected to fall short of the 2015 'good' status target in 2012-2013, 62% in Northern Ireland, 50% in Wales and 38% in Scotland,[69] compared to an EU average of 47%.[70] Diffuse pollution from agriculture (phosphorus, nitrates and fine sediment) is cited as the likely cause in 28% of known failures to achieve good status in England;[71] Defra is consulting on legislation to address this.[72]

million tons of plastic (MT) generated in 2010 by 192 coastal countries, 4.8-12.7 MT entered the oceans, which is expected to increase by ten times by 2025.[73] Micro-plastic (fragments of less than 5mm) are of concern because of their toxicity and size (readily ingested by organisms),[74] and are expected to increase in concentration with growing global plastic consumption.[75]

Humans exert multiple pressures on 41% of the marine area,[76] and now exploit nearly 40% of the ocean's productivity (through fishing), up from 15% in 1950.[77] Globally, around 30% of fish stocks are defined as overfished, which reduced the total biomass of predatory fish species by 54% in the last forty years.[78] Fishing also has other impacts, such as the destruction of seafloor habitats by bottom trawling and the killing of non-target species.[79] The International Council for the Exploration of the Sea estimated in 2011 that 47% of shared fish stocks around the UK were fished sustainably (up from 33% in 2008). Only 3.27% (12 million km^2) of the oceans had been designated as a protected area by the end of 2013, only 1.9 million km^2 of which are areas closed to fishing.[80] Under various EU, English, Scottish, Welsh and Northern Irish legislation 16% of UK waters are designated as marine protected areas, but most are not closed areas.[81] 27 marine conservation zones have been established in English waters (POSTnote 437) and a further 23 sites proposed.[82]

Terrestrial Environment

The land area of the world is approximately 13 billion ha (100ha=1km^2). Converting natural habitats into agricultural land (land use change) is the primary driver of terrestrial biodiversity loss and is projected to account for 70% of future loss. In 2013, 38% of land was classified as 'agricultural area' (this is 4,889 million ha and includes arable land, permanent crops and permanent meadows and pastures).[83] In 1990, 32% of land area was forest (4,128 million ha); by 2015 this area had decreased to 31% (3,999 million ha). 250 gigatonnes (Gt) of global carbon stocks are presently stored in forest biomass (POSTnote 466), this has decreased by almost 17.4 Gt over the last 25 years.[84]

However, the net loss of natural forest (Figure 2) has decreased from 8.5 million ha per year in the 1990s to 6.6 million in the last five years: 8.8 million ha are lost per year and 2.2 million gained through abandonment of agricultural land.[84] Over half the world's agricultural land is subject to soil erosion (reduction in soil depth), with soil degradation a leading cause of abandonment. Soils store three times as much carbon as is contained in the atmosphere; degradation of carbon-rich soils, such as peatlands, release significant quantities of CO_2 (POSTnote 502). Urban areas and infrastructure only occupy 2% of the land area, but this may double by 2050.[2] Globally, 13% of land is in nationally designated protected areas for biodiversity,[85] with 30% of the UK land surface in protected areas.[86] The most dominant UK land cover type is agricultural land (74%), followed by forest and semi-natural vegetation. Only 8% of the UK is covered by artificial surfaces. Between 2006 and 2012, there was an expansion of urban areas, converting 14,000 ha of agricultural land, 7,000 ha of forest and over 1,000 ha of wetlands to artificial surfaces.[87]

Reducing Pressures

The main drivers of environmental change over the last 50 years have been human activities to increase the provision of goods such as food, fuel and water, and the emission of wastes. Plausible pathways exist for reducing these pressures on the environment, which require more efficient use of land, water, energy and materials. For example, increasing agricultural yields while reducing environmental impact (sustainable intensification) through measures such as adopting precision farming technologies (POSTnote 505). There are a number of other approaches available:

- The Natural Capital Committee has highlighted that projected population increases will intensify pressures on declining natural capital in England and recommended a range of measures to address this including the restoration of natural capital assets (such as soils).[12]
- As noted in a recent Environmental Audit Committee report,[88] innovative technology could support circular economy approaches. This would optimise the value obtained from natural resources, eliminate waste by improving the design of materials, products, systems and business models, and uses waste and end-of-life products as sources for materials.
- Sustainable development seeks to maintain and enhance human wellbeing within finite planetary resources (POSTnote 408). The recently agreed UN 17 Sustainable Development Goals include goals and targets relating to climate change, restoring terrestrial ecosystems and marine resources.[89]

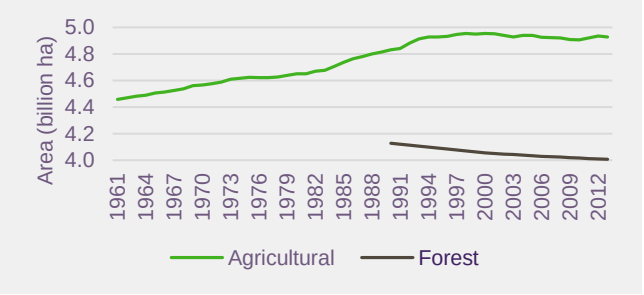


Figure 2. Global Forest and Agricultural Area 1961-2013[83]

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