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UK SOIL DEGRADATION

Soil degradation involves both the physical loss (erosion) and the reduction in quality of topsoil associated with nutrient decline and contamination. It affects soil quality for agriculture and has implications for the urban environment, pollution and flooding. Currently, 2.2 million tonnes of topsoil is eroded annually in the UK and over 17% of arable land shows signs of erosion[1]. This POSTnote examines the nature and extent of soil degradation in the UK and the challenges and opportunities for soils in a changing climate. These include the potential for using degraded and polluted soils in the built environment for brownfield redevelopment as well as the possibility of using soils to mitigate carbon emissions.

Background

Soil supports agriculture, wildlife and the built environment, filters water, stores carbon, and preserves records of the ecological and cultural past[2]. Soil degradation can be the result of one or more of several factors. All of these are identified as potential threats to soils in the UK and are examined in this POSTnote:

- Physical degradation (erosion, loss of structure, surface sealing and compaction);
- Chemical (pollution) and biological (loss of soil organic matter and biodiversity) degradation;
- Climate and land use change (which may accelerate the above factors).

Physical degradation

Soil erosion can occur by wind or water. It is a natural process, accelerated by human activity and is effectively irreversible. Erosion by water is more widespread than wind erosion in Britain (Figure 1). Though wind erosion is more limited in area and frequency than water erosion, where it does occur, it is generally more severe. The rate of soil erosion by water in the UK has been estimated at 0.1–0.3 tonnes per hectare per year.

Figure 1 – Areas potentially at risk of soil erosion[3]

It has been estimated that 44% of arable land in the UK is at risk of water erosion[4]. Around 20% of upland peat, shallow, and rocky soils (shown as 'upland' on Figure 1) are currently eroding[5]. An equivalent area of lowland peat is affected by commercial extraction, with impacts for the amount of carbon stored in it (see Box 1). Soil erosion by water in the UK results in loss of productive soil and nutrients in the immediate vicinity ('on-site'). Further away ('off-site'), eroded soil can block water courses and drains, affect fisheries, and increase the risk of flooding.

Box 1. Peat erosion

- The UK has around 15% of the world's blanket peat, a unique ecosystem that covers around 8% of the UK land area, mainly in upland Britain. Peatlands are important repositories of carbon, biodiversity, and records of past environmental conditions.
- Peat erosion occurs by a combination of drying out and vegetation loss in dry conditions and erosion by water in wet conditions.
- Globally, peat accounts for around 50% of terrestrial carbon storage. Peat contains as much carbon as is present in the atmosphere.
- The UK Climate Impacts Programme[6] predicts warmer summer temperatures and winter storminess, which may accelerate peat erosion and lead to release into the atmosphere the carbon currently stored there. There is a risk that a 'positive feedback' could arise between release of carbon from eroding peats and further global warming and peat erosion.

Eroded soil can be deposited on roads and other infrastructure leading to significant clean-up costs. It can also silt up reservoirs and harbours, reducing the lifetime and adding to the maintenance costs of these structures and put pressure on aquatic life. The costs of damage to agricultural soil in England and Wales have been estimated as £264 million a year and the costs of treating water contaminated with agricultural pollutants as £203 million a year[7]. As illustrated in Box 2, changes in local land management practices can greatly influence soil erosion by water.

Box 2. Muddy flooding on the South Downs

Inundation of properties by muddy floodwater occurred frequently on a housing estate on the edge of Sompting, a town in West Sussex, in the late 1980s and early 1990s. This was largely due to the practice of growing winter cereal crops on the South Downs, which was widespread and subsidised by the EU at that time. This left bare soil exposed at the wettest time of the year, leading to soil and water runoff during rainfall, which blocked drains and watercourses, and eventually flooded properties with mud-laden water[8].

Changes in land management practices occurred in response to the floods in the early 1990s and included reversion of some winter cereal fields to permanent grassland under the EU's Set Aside scheme. This reduced both runoff and soil erosion by disrupting the downhill flow that flooded the housing estate. No muddy floods have occurred in Sompting since these measures were adopted, even in the exceptionally wet autumn of 2000. In other parts of the South Downs, particularly around Brighton and Lewes, muddy flooding has continued to be a problem. The option of reverting winter cereal fields to grassland in these areas remains, and incentives are available for farmers to do this under existing government policies.

Chemical and biological degradation

Diffuse pollution and soils

Diffuse pollution is contamination that comes from many individually minor, dispersed sources. In both rural and urban areas, pollutants can be washed by rainfall both into the soil and from soil into watercourses. Pollutants can include eroded soil, nutrients, and fuel. The UK is obliged under the EU Water Framework Directive (WFD) to achieve what is broadly defined as 'good ecological status' by 2015 in all inland and coastal waters. The combined pressures from diffuse pollution may put over 80% of rivers, over 50% of lakes, around 25% of estuaries and coasts and 75% of groundwaters at risk of not achieving WFD objectives.

Biological degradation

Many key soil functions are underpinned by biodiversity and organic matter. Organic matter enters soils principally from plant remains and organic manure additions, and is primarily made up of carbon, nitrogen, and phosphorus. Biodiversity and organic matter can decline due to erosion or pollution, leading to a reduction in soil functions such as control of water and gas flows. The Department for the Environment, Food and Rural Affairs (Defra) is currently funding projects that aim to develop indicators and soil management guidelines to monitor and maintain soil biological functions.

Urban soil degradation

Urban soils can be degraded by pollution, removal or burial. Soil quality can be affected by building waste and soils may become contaminated by heavy metals, hydrocarbons and pathogens. Construction effectively seals the soil surface and reduces its capacity to store water, which may exacerbate flooding. The role of soils in urban areas has so far been neglected compared with rural soils. The government is committed to the sustainable use and protection of urban soils. A number of schemes are in operation which aim to replace some functions lost from degraded soils, such as:

- maximising the use of construction, demolition and excavation waste through screening to separate aggregates and soils that can be recycled;
- using permeable paving and vegetated (usually grassed) roofs in new buildings which increases water storage and reduces urban flooding potential.

Climate change

Current projections of global climate change suggest that between 1.4 and 5.8°C of warming will occur this century[9]. Most parts of Britain will also experience more seasonal extremes of rainfall: wetter, stormier winters and drier summers. Changes to how land and soil are managed in response to climate change will possibly be more important than changes in the soil due to the climate. Wetter winters may lead to increased muddy flooding unless land use changes are made (see Box 2). Drier summers, on the other hand, may mean wind erosion becomes more of a problem as soils dry out. This may bring problems with air quality and visibility, and possible adverse health implications. However the total area affected by wind erosion, as at present, is still likely to be less than that experiencing water erosion.

Loss of carbon

Changes in the temperature and moisture of soil may speed up the decomposition of organic material, reducing the amount of carbon in the soil and increasing emissions to the atmosphere. This may to some extent be counteracted by higher uptake of carbon dioxide by

plants as they grow faster in warmer conditions and store carbon as biomass both in the soil and the plant. The overall effect of this is projected to be a balance between carbon uptake and emission from soils in a warmer Britain[10]. UK soils could offer the potential to act as a store of carbon, which may offset industrial and domestic carbon emissions (see Box 3). Soil carbon levels and land use changes are currently being modelled for a national carbon dioxide inventory, and Defra is due to publish the results in summer 2006.

Box 3. Soil carbon sequestration

Recent projections have shown that there is a potential for UK soils to take up ('sequester') carbon dioxide (CO_2 – the principal greenhouse gas involved in climate change). One research group has estimated that the measures below in combination could help meet part of the UK's obligations to cut CO_2 emissions under the Kyoto Protocol[10]. There is still considerable uncertainty concerning the amounts and nature of sequestration and how it can be audited. There are also concerns about the lack of permanence and a possible reduction in effort on more permanent carbon reduction initiatives. Carbon sequestration methods include:

- minimising soil disturbance through reduced cultivation techniques and/or reversion to grassland and forest. This also reduces carbon emission from vehicle use;
- growing crops that efficiently fix carbon in their biomass, such as willow, poplar and perennial grasses;
- incorporating animal manure, sewage sludge, compost and straw into the soil to increase the organic carbon component. This may not immediately increase its carbon content of soil but has co-benefits such as nutrient addition and improved soil structure.

The policy framework

To an extent, soils are public goods which provide natural resources and ecosystem 'services' such as support for wildlife and transformation of pollutants. Since many soils are privately owned, effective regulation and partnerships are needed to protect them. Defra has responsibility for overall soil policy in England; the Environment Agency (EA) for environmental protection in England and Wales; and the new Department for Communities and Local Government (DCLG) for planning policy. Scotland, Wales and Northern Ireland have separate devolved bodies that deal with soil. This note deals primarily with soils in England. Recent progress on soil policy has been the establishment of a specialist soils unit at Defra and subsequent publication of a Soil Action Plan for England (2004). Defra is currently drafting a paper setting out the next phase of soil protection in England from 2007. The devolved administrations plan to carry out similar work.

In 2002, the European Commission adopted a Communication 'Towards a Thematic Strategy for Soil Protection'. Its proposals cover priority issues such as erosion, loss of organic matter, compaction and sealing, landslides, and contamination. The European Commission is likely to publish a Soil Framework Directive by the end of 2006. Urban soil protection generally lags behind rural soil protection, but policies to address urban soil degradation are now being developed.

Rural setting

Single Payment Scheme (SPS) and cross compliance

Reform of the Common Agricultural Policy in 2005 decoupled subsidies from production. Support is now in the form of a single payment conditional on land managers maintaining their land in good agricultural and environmental condition. Defra has developed a number of cross compliance requirements for soils (see Box 4). All SPS applicants must complete and implement a Soil Protection Review as part of their cross compliance requirements and review it annually.

Environmental Stewardship

This is a voluntary two-tier agri-environment scheme launched by Defra in 2005. The entry level scheme allows land managers to choose a number of 5-year management options. Around 40% of the 20,000 participants to date have chosen to complete a soil management plan, one of the highest take-ups of all the options. A higher level scheme goes further and offers 10-year options for protecting environmental features in priority areas.

Box 4. Mitigation strategies for soil degradation

The Soil Protection Review is carried out by farmers as part of cross compliance[11]. It involves identifying soil issues, deciding on measures to manage and protect soils, and then reviewing success. Some of the options to protect the soil from physical decline and erosion (none of which are compulsory) include:

- reducing mechanical operations on wet ground;
- planting crops early in autumn with coarse seedbeds;
- working across slopes where safe to do so;
- using low ground pressure set-ups on machinery;
- shepherding livestock and moving forage areas;
- planting and/or maintaining hedges or shelter belts to reduce wind erosion.

Measures to protect soil organic matter include:

- returning straw or other crop residues after harvest;
- including grasses in crop rotations;
- applying animal manure, compost or sewage sludge;
- using reduced or shallow cultivation to maintain or increase near-surface organic matter.

Water Policy

Part of the EU Water Framework Directive involves controlling diffuse pollution from soil, including nitrate and phosphate from agricultural sources, for individual river basins. There is a mandatory action programme for Nitrate Vulnerable Zones which is being revised. Another approach is being implemented through the England Catchment Sensitive Farming (CSF) initiative. This targets 40 priority catchments chosen as part of a £25m 2-year trial to raise awareness of and help tackle diffuse water pollution from agriculture. Dedicated CSF Officers engage with farmers and encourage adoption of land management practices that mitigate diffuse water pollution.

Urban setting

The planning system

The recently reformed planning system requires sustainability appraisal and strategic environmental assessment of all spatial plans. An environmental impact

assessment is required for major development proposals. Both procedures explicitly require consideration of impacts on soils. Brownfield sites are now prioritised for development in urban areas. Treatment of contaminated sites often involves digging out contaminated soils and disposing of them in landfill. This may simply move the problem somewhere else. However some soils can now be decontaminated on site. This is more expensive for the development but more sustainable in the long term.

Future challenges and opportunities

Soil issues have in the past been fragmented at policy level and only recently have been brought together in a consistent framework to address degradation. Soils are still considered as a secondary issue in many urban and rural policies primarily designed to address pollution and water quality. It may be too early to assess the effectiveness of these policies on soils, and it could be several years before their impact is seen. Defra aims to consult on the policies to tackle diffuse water pollution at the end of 2006. The need for long term planning, especially for climate change, remains. Managing soils to meet future challenges could be incorporated effectively into existing policies.

One approach to soil protection in the future might be to incorporate some of the targeted voluntary policies under the higher level environmental stewardship scheme into compulsory cross compliance measures. However, there may be difficulties in implementing this under the current cross compliance regulations and it may present costs to the farmer. The view among stakeholders such as the National Farmers' Union (NFU) and Country Land and Business Association (CLA) is that in future soil degradation could be addressed through voluntary agreements rather than regulation. One key remaining issue for researchers and policymakers is whether they sufficiently understand the causes of degradation or the mitigation measures required to engage effectively with farmers and land managers in addressing them. The variety of soil types in the UK means that there is no 'one size fits all' solution to degradation. This problem may be compounded by lack of knowledge about many soil processes, and a shortage of skills in soil science and management[12].

Soil organic matter

Organic matter is vital for the physical, chemical and biological functioning of soils. Around 18% of the organic matter present in arable topsoils in 1980 had been lost by 1995. One of the reasons for this was that grasslands were ploughed for arable use. Some experts consider that the amount of organic matter in some soils may now be reaching such low levels that crop production may not be sustainable in the long term. As organic matter declines, so does the soil structure, so that the soil becomes more susceptible to physical erosion. Steps being taken to address loss of organic matter from soils include recycling farm manures, sewage sludge, and composted green wastes in soils. However, injudicious application of these organic materials may lead to diffuse water (nitrate and phosphate) pollution, and air pollution (odour and ammonia). The challenges in future are to maintain and where possible enhance soil organic matter while minimising the polluting effects of applying organic materials.

Supportive measures

Some stakeholders suggest that good policies already exist but need better co-ordination. Continued targeted advice, information, monitoring and voluntary partnership approaches may allow further uptake. Most farmers now address soil degradation, but those who do not may cause the worst off-site impacts. Voluntary Land Care partnership initiatives, where farmers, local authorities, government agencies and advisers have worked together to address problems and promote 'win-win' situations, have been well received by stakeholders such as the NFU and CLA[13]. However, while they appear to address some issues in the short term (by, for instance, changing the timing of crop planting) there is concern that they lack the necessary rigour to address the fundamental causes of long-term soil degradation (sometimes inappropriate land use).

Overview

- Soils are often seen as a wholly rural issue, but it is important not to overlook urban soils, which are now being taken more into account in the planning system
- Soil degradation is a natural process, accelerated by human activity. It has both localised and widespread impacts.
- Policies, backed by incentives, are beginning to address degradation, but uncertainties remain as to how effective they are. This is compounded by a lack of knowledge of the interactions between soil, water, air, and climate change.
- Protection of soil needs to be carried out as part of a holistic approach that includes protecting other parts of the environment from the effects of soil degradation.

Endnotes

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POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to Jonathan Butler for researching this briefing, to the Natural Environment Research Council for funding his parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact Kate Trumper at POST.

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