UNIVERSITY OF PLYMOUTH

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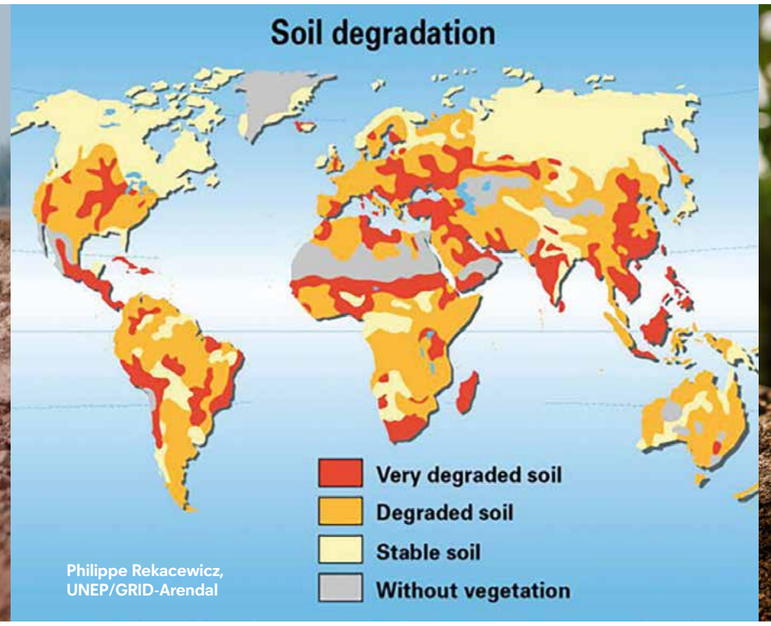
RESPONDING TO THE UK'S SOIL CRISIS

"The nation that destroys its soil destroys itself" President Franklin D Roosevelt, February 1937.

Summary

Humans have relied on soils for millennia but, globally, soil health is threatened, particularly by climate change. The past decade has seen a growing policy interest in soils, as the impacts of soil degradation on carbon stocks and the wider ecosystem have come under scrutiny. Government policies across the world are starting to reflect the need for soil protection. However, implementing such policies effectively will require a significant cultural shift. Reconstructed soils and regenerative agriculture can be part of the solution to improve soil health and mitigate climate change. Global targets for soil health and its carbon stores must also be part of any serious efforts to reverse its decline.

"Such large quantities of soil ending up in landfill sites is an indication of the low interest value accorded to the soil by UK citizens, society, politicians and policy makers, even though soil has a key role to play in mitigating climate change."



Key points

- The UK is suffering from extensive soil degradation, leading to loss of carbon, nutrient imbalances, erosion, compaction, and contamination.
- Soil disposal makes up over half of the UK's landfill volume, with most of this originating from civil engineering projects and housebuilding. Separating soil from its natural environment means that it is effectively 'lost', and also leaves the problem of soil disposal.
- The UK urgently needs a policy and regulatory system to discourage soil ending up in landfill.
- Soil 'waste' should be seen as a potentially useful, life-giving resource. Changes to the management of agricultural soil could contribute to improving the ability of soils to produce crops, as well as to wider benefits including mitigating future climate change.
- Without urgent action, the UK's soil quality could degrade to such a degree that it no longer provides sufficient food for the population.
- Research provides evidence for practices, such as reconstructed soil and regenerative agriculture, that could be used to reverse soil degradation and erosion.

Context

Soil sustains life on the planet. It consists of minerals, organic matter (specifically the material left over from decomposing plants and animals), organisms, water and gases. It underpins the food system, contains nutrients and stores water for plants to grow. It supports biodiverse habitats; one gram of soil contains tens of thousands of microbial species. Soil acts as a filter for water, so it enters rivers more purified, and plays a key role in flood management, holding water after heavy rainfall. It also offers the most significant carbon storage system on earth, helping to regulate the climate.

The Issue

Despite its life-giving properties, soil is in crisis across the world. Along with the effects of intensive agriculture, a growing population has caused changes to land use with de-forestation and the conversion of rain forests to land for pasture. Soil erosion, listed in a recent UN analysis as one of the key threats to the soil system, impacts on water quality. Loss of soil from the land leads to the build-up of silt in rivers, affecting water quality and long-term ecosystem health. It can also compromise energy security; soil coming off fields and hillsides turns into silt that can block hydropower dams.

It is claimed that 3cm of topsoil is generated every 1000 years yet in England and Wales roughly 2.9 million tonnes of topsoil are eroded annually.Unless urgent action is taken, the UK's soil quality will have degraded to such a degree that it may no longer provide sufficient food for the population. Food security would then be compromised. Most soil in England is either 'degraded' or 'very degraded'. Once soil becomes degraded, it can potentially emit greenhouses gases: carbon dioxide, methane and nitrous oxide.

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Growing crops consistently, without attention to soil carbon stocks, decreases the nutrient status of soils. The response has been to add artificial nitrogen and phosphorous to the soil to retain productivity. Intensive farming has resulted in soil releasing nutrients at a scale that can stimulate algal blooms, by upsetting the nutrient balance in water systems.

Up to 3.9 million ha of agricultural land in England and Wales are at risk of compaction. The risk is increased for heavy clay soils during wet periods. Heavy machinery use and intensive grazing increases soil compaction, compressing the soil structure and reducing porosity (air spaces), nutrient cycling and gas exchanges, limiting productivity. Climate change is also impacting soil health. Extreme climate events are occurring more frequently; some areas of the UK have seen more regular heatwaves in recent years whilst others have experienced repeated heavy rainfall. This affects the land by making it inaccessible and unusable for a specific timescale, destroying crops and adding to food insecurity.

Another challenge is to encourage people's engagement and understanding of soil, at individual, societal and political levels. There has also been a lack of political leadership and commitment to managing and improving soil health, despite its key role in mitigating climate change.

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Addressing the issue

The UK is at a crossroads in deciding how it approaches soil management. The complexity and relatively low environmental priority of soil creates significant challenges to future soil management but, already, there is a lot of knowledge and expertise available which could help address the issue. The UK Government's Soil Health Action Plan for England intends to address the challenge of increasing soil degradation by supporting the 25-year environment plan ambition for sustainable soil management by 2030. The scale of this crisis is finally appearing high on international political agendas too.

Landfill and soil waste

More needs to be done in the UK to discourage soil ending up in landfill. DEFRA's 2021 statistics on waste show that 58 % of landfill volume is soils, most of which was removed for civil engineering projects and housebuilding. The situation is deeply ironic: removing and separating the soil from its natural environment means that it is effectively 'lost', yet this also leaves the problem of having to dispose of the removed soil.
The UK urgently needs a policy and regulatory system to stop this huge amount of soil waste going to landfill.

There are potential risks associated with soil when it is displaced, whether by industrial extraction processes and landfilling, or through erosion and climate pressures. The current Waste Strategy for England ignores the loss of soils to landfills despite these the two issues being connected. This needs to be addressed. Such quantities of soil ending up in landfill sites is an indication of the low interest value accorded to the soil by UK citizens, society, politicians and policy makers.

There has been a tendency to overlook the benefits of bringing displaced soil back into its own environment. Soil 'waste' should not be seen as waste but as a potentially useful, life-giving resource. Once the soil leaves a slope and becomes silt, it switches from being perceived as a resource to a pollutant, yet it still contains the nutrients that have been taken from the land. There needs to be more joined-up thinking about retrieving and reusing that sediment to regenerate the landscape.

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Carbon storage

When soil is damaged, it cannot perform the essential task of storing carbon. Greenhouse gases are emitted in greater amounts, causing temperatures to rise, and increasing air water pollution. Lateral diffusion transfers nutrients to water and leads to degradation of aquatic ecosystems, placing an even greater strain on an already struggling planet. Peat is one of the best long-term carbon stores, yet it has been harvested at an alarming rate to enrich compost sold for gardening. The unsustainable cutting of peat has been very harmful. Gardening has created huge pressures on the land despite the availability of alternative solutions, such as composting, which can create an effective growing medium.

Water regulation

Uncompacted soils allow water to infiltrate, reducing surface runoff and the leaching of nutrients into water bodies during wet weather. Soils also retain water for plants to access during drier periods. Replacing soil with a hard surface such as concrete can have a significant effect. Over a large area it becomes problematic. Soil that has been concreted over cannot hold rainwater. Private citizens need to consider the impact and consequences of garden landscaping and home refurbishment decisions more deeply. Regulation could play a part here. People could be given carbon credits for not paving over soil. Vegetated gardens, even on a small scale, could make a difference. These tangible examples could enable people to engage with, and contribute to, improving soil health. It is important to teach school children about soil and to give them the chance to grow plants in pots.

Regenerative agriculture

Soil degradation resulting from poor management practices, intensive agriculture and climate pressures could be reversed by restoration. A productive soil for agricultural use should contain a balance of nutrients (e.g. carbon, nitrogen and phosphorous) and minerals (e.g. calcium and zinc), as well as appropriate organic material. Re-generative agriculture, whereby farming and grazing practices rebuild soil organic matter and restore degraded soil biodiversity, supports a more holistic approach where farming is in harmony with soil health. Farmers need to be incentivised to farm in a more regenerative way; many have, up until now, massively over-fertilised soils in the belief that doing otherwise would result in a reduced yield. There is a mistaken belief that the soil can look after and re-generate itself regardless of how it is managed. Whilst the 2022 Sustainable Farming Incentive scheme will pay farmers to manage the soil differently, it is not clear if the level of payment will be enough to incentivise change.

Reconstructing soil

Lost soil can be reconstructed. This could reduce the pressure on valuable topsoils and support both sustainable development and food security. Inert materials (a by-product of industrial operations) can be mixed together to create a substrate with the characteristics of a healthy soil. This can be used in the manufacture of topsoils for urban grasslands, and materials for high-value markets, such as horticulture and agriculture. Cornwall's Eden Project is an impressive example of infrastructure built using reconstructed soil in 8 hectares of a former sand quarry. Here, more than 80,000 tonnes of reconstructed soil were made by mixing locally-sourced, readily-available waste materials. The resultant soil has a much higher organic component than natural soil and has provided an excellent laboratory to assess the potential of reconstructed soils and how they might be optimised for widespread use. The team at the University of Plymouth has produced soils from suitable waste materials, working to improve their efficiency and nutrient retention, and influence both their deployment and the regulations surrounding their use. This work hopes to demonstrate the potential of reconstructed soils as a viable option for communities across the world who need to rebuild their soil resources.

The components of natural soil can be varied but it is possible to develop reconstructed soils that potentially function better than natural soils. There is an obvious link here to material reuse, the circular economy and carbon capture. Another benefit of soil creation is that it can be made to a specification. A safe and high-performing reconstructed soil deployed for food growth would be a precious resource in efforts to achieve environmental sustainability. Continued monitoring will be key. Depending on the application, the health of reconstructed soil needs to be assessed for its suitability for food production, gardening etc, based on its location. For example, if it were situated close to a water course, and leached a lot of nitrogen, this could have a negative impact on water quality. If monitoring shows that the microbial community in the soil is not fit for purpose, this can be amended. Once the soil becomes `living' it will need to be assessed at regular intervals to ascertain how well nutrients and other quality indicators are being retained. It will also be important to understand how such soils function in the long term, and to what extent their chemistry and biology should be regulated. Regulation and policy must keep pace with scientific progress if climate emergency declarations are to become more than rhetoric.

Composition of soil reconstructed from waste materials and deployed at the Eden Project, Cornwall, UK:
25% sand
10% lignite clay
32.5% composted green waste
32.5% composted bark

Land management

The nutrient content of soil differs depending on land use and management. Sustainable soil management seeks to optimise different functions to increase soil resilience, depending on the main land use, such as food production or flood prevention. Changes to the management of agricultural soil could significantly improve the ability of soils to produce crops, and offer wider benefits including mitigating future climate change (agriculture accounts for 68 % of UK emissions of the greenhouse gas nitrous oxide). To develop effective solutions, scientists need to embark on extensive monitoring and data collection. This would be helped by employing a whole-system approach involving natural and social scientists, communities, industry and policy makers. The time in which environmental stewardship strategies can be developed is limited. It has to happen now.

Dr Kate Schofield undertakes research as part of the ReCon Soil project creating reconstructed soils from waste

Supporting Literature

Does carbon limitation reduce nitrogen retention in soil? Schofield et al. (2018) https://pearl.plymouth.ac.uk/handle/10026.1/10474

DEFRA Agri-Climate Report 2021 https://www.gov.uk/government/statistics/agri-climate-report-2021/agri-climate-report-2021#section-1-uk-agriculture-estimated-greenhouse-gas-emissions

Environment Agency, June 2019, The state of the environment: soil https://assets.publishing.service.gov.uk/government/uploads /system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf

UNIVERSITY OF PLYMOUTH
Sustainable Earth Institute

Evidence summary for policymakers

Relating to the following Global Sustainability Development Goals

A three-time winner of the Queen's Anniversary Prize for Higher and Further Education, the University of Plymouth is renowned for high quality, internationally-leading education, research and innovation.

The **Sustainable Earth Institute (SEI)** connects the University's world leading research expertise with the wider world to collaborate on creating a more sustainable future. We bring together researchers from natural and social sciences, engineering, arts, humanities, health and business, to take an interdisciplinary, systems-thinking approach to help tackle sustainability challenges.

This Policy Brief is part of a series aiming to inform policy-makers of our sustainability research, in particular around Net-Zero Carbon and Healthy Landscapes.

To read more in the series visit:
www.plymouth.ac.uk/sei-impact

Voice of a sustainable earth

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Professor Mark Fitzsimons is a Professor of Environmental Chemistry and leads the Biogeochemistry Research Centre. He is a leading researcher on the interactions of nitrogen and other chemical compounds in the marine and terrestrial environments. His interest in nitrogen has spanned the measurement of trace gases in the Southern Ocean, the environmental fate of pharmaceuticals in water and sediments and investigating the chemistry of reconstructed soils made from inert waste materials.

The University of Plymouth has a national and international track record in specific areas of data acquisition as well as the interpretation and visualisation of environmental data. It is currently working to draw these strengths together to deliver the next generation of environmental monitoring and assessment. Building on research bases within environmental monitoring and fate, sensors, agri-tech, and biology we have formed a University-wide Sensors group, which is already forging new collaborations and gaining funding.