2015

European Commission

SOIL - WHAT IS IT GOOD FOR?

Soil functions: keeping the Earth alive

World Soil Day
December 5th

Joint Research Centre

2015 International Year of Soils

Supporting the International Year of Soils

Soil functions: keeping the Earth alive

Most people are unaware of the multitude of services that are provided by soil, many of which are vital to support life.

"Essentially, all life depends upon the soil ... There can be no life without soil and no soil without life; they have evolved together."
Charles E. Kellogg, USDA - Yearbook of Agriculture, 1938

Soil is one of the fundamental components that support life on the planet

The soil functions described in this calendar are vital to life on Earth. However, not all soil types can carry out these functions to the same extent, and some are more susceptible than others to failure when they are put under stress. A clear understanding of the functional capabilities and potential of different soil types is thus vital for planning and managing the sustainable development of soil resources, wherever they are found.

- Plants and crops are dependent on soil for the supply of water and nutrients, and as a medium in which to grow.
- Soil stores, filters, buffers and transforms substances that are introduced into the environment. This capability is crucial for producing and protecting water supplies and for regulating greenhouse gases.
- Soil is a provider of raw materials.
- Soil is also an incredible habitat and gene pool – more than five tonnes of living organisms can exist in a hectare of arable soil.
- Soil is a fundamental component of our landscape and cultural heritage.

2015 International Year of Soils

2015 was declared the International Year of Soils (IYS) by the 68th UN General Assembly. The IYS aims to be a platform for raising awareness about the importance of soils for food security and essential ecosystem functions.

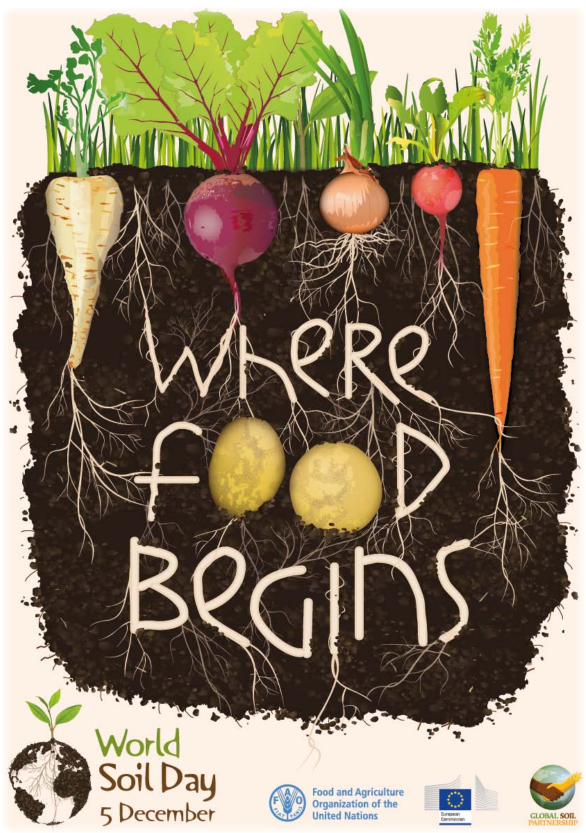
The main objectives of the IYS are to:

- Raise full awareness among civil society and decision makers about the profound importance of soil for human life;
- Educate the public about the crucial role soil plays in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development;
- Support effective policies and actions for the sustainable management and protection of soil resources;
- Promote investment in sustainable soil management activities to develop and maintain healthy soils for different land users and population groups;
- Strengthen initiatives in connection with the Sustainable Development Goals (SDG) process and Post-2015 agenda;
- Advocate for rapid capacity enhancement for soil information collection and monitoring at all levels (global, regional and national).

December 5th - World Soil Day

Soils have been neglected for too long. We fail to connect soil with our food, water, climate, biodiversity and life. We must overcome this tendency and adopt some actions to preserve and restore soils.

The World Soil Day campaign aims to connect people with soils and raise awareness about their critical importance in our lives.



No soil... no buffering of pollutants

JANUARY 2015

One of the key functions of soil is to act as a natural purification system. Over time, soil can filter, absorb and transform substances. Chemical compounds can become trapped in the soil, which stops them reaching clean water supplies. Also, pollutants can be degraded or otherwise kept from plants and animals through a range of biogeochemical soil processes. On the other hand, the soil can slowly release excess nutrients to the environment for use by plants, hence contributing to a lower usage of fertilisers. However, high levels of toxins or severe soil degradation can disrupt these processes, leading to a loss of this purification function.

The photograph above shows buffer strips at the edge of a field that interrupt the movement of agro-chemicals (nitrogen, phosphorous and pesticides) and sediments from arable land to surface waters.

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No soil...
no animal feed and fodder

FEBRUARY 2015

One of the most widely recognised functions of soil is as the material in which plants grow. In turn, many of these plants are used as feed or fodder for animals. Fodder refers to the food that is given to animals (including plants that are cut and carried to them) rather than the food which they forage for themselves. It includes hay, straw, silage, compressed and pelleted feeds, grains and legumes. Globally, feed grains are the most important source of animal feed. Cows and sheep need 8kg of grain for every 1kg of meat they produce, pigs need about 4kg, while 1.6kg of feed is required to produce 1kg of chicken. Many farmed fish are also fed grain! It's estimated that about half of global maize produce and 40% of global soya produce is used for animal feed.

The photograph above shows a grass meadow, which is traditionally cut for hay or used by grazing animals. Grass meadows are also important for biodiversity, soil carbon sequestration and water management.

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No soil...
no natural fibres or timber

MARCH 2015

An important function of soil is as the medium that supports the production of biomass, which is often used to produce natural fibres and timber. Natural fibres can be collected from seeds or seed cases (e.g. cotton), leaves (e.g. sisal, banana), plant stems (e.g. flax, jute, hemp, rattan) and fruit (e.g. coconut (coir)). Increasingly, plant stalks of many agricultural crops (e.g. maize, wheat) are being used to produce biofuels. Fibres are actually the stalks of the plant. For thousands of years, wood has been used in construction, for making furniture and utensils, and as a fuel.

The photograph above shows felled tree trunks which are stored for later processing. Timber can be sent to a mill to be made into paper or into lumber for construction or making furniture. In many parts of the world, deforestation or clear-cutting can lead to soil degradation such as erosion or loss of organic matter.

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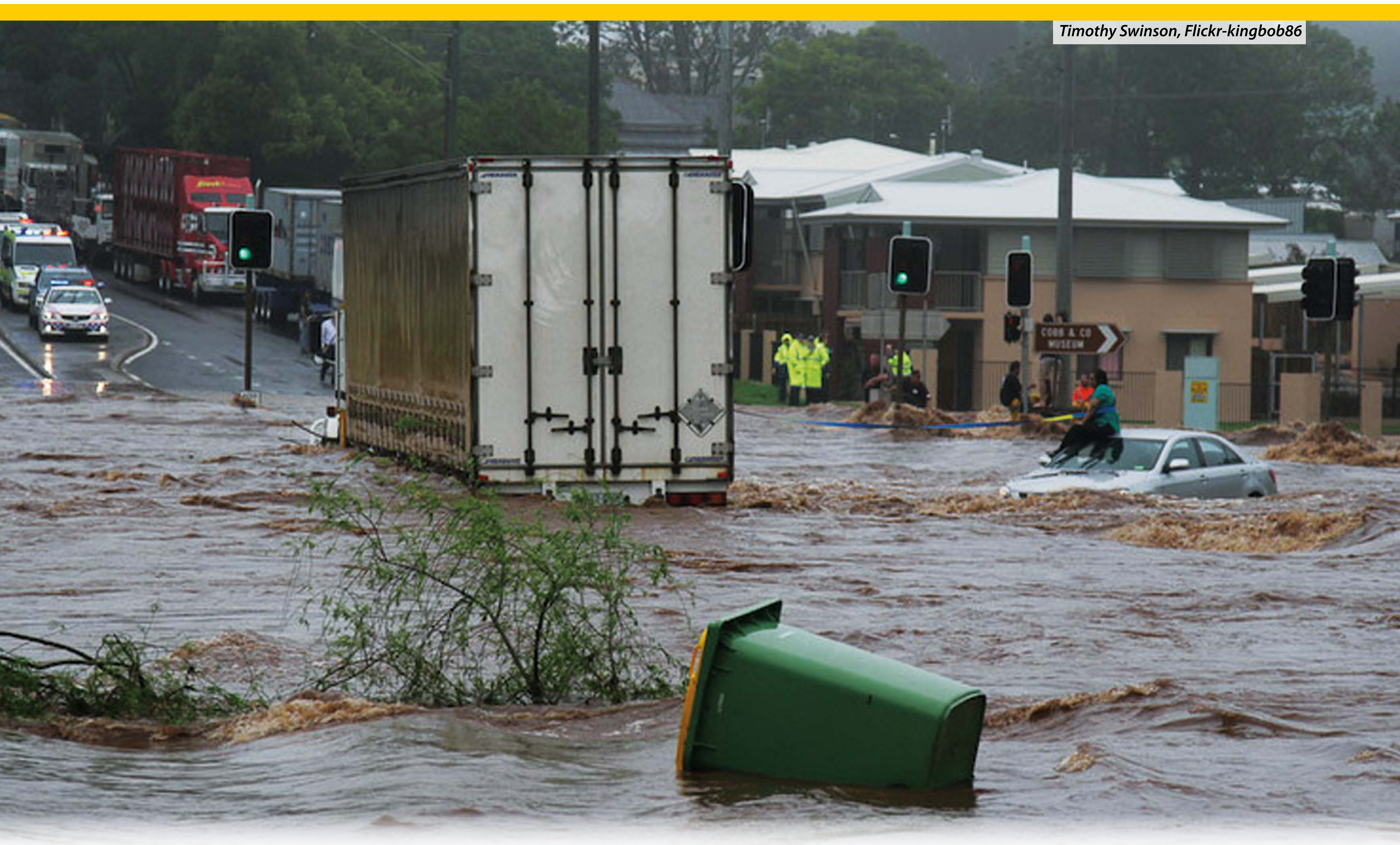
No soil...
no water storage

APRIL 2015



Timothy Swinson, Flickr-kingbob86

Soil is a key regulator of water flow. Soil can absorb much of the rain that falls on it, but the amount varies according to the soil's texture, structure, organic matter content and vegetation cover. Well-structured loamy soil under grassland or woodland acts as a sponge and can absorb as much as 40% of its volume as water. Soil also acts as a tap, turning water flow on and off by storing and releasing water for plants when needed. Urban planners now realise that the sealing of soil by materials such as concrete and asphalt, together with compaction of the subsoil, significantly exacerbates the risk of floods from heavy rainfall. Any reduction in the capacity of soil to absorb water will lead to increased overland flow and the rapid transfer of rainfall to river channels, leading to flooding and erosion.

The photograph above shows a flooding event in an urban area. The colour of the water indicates a high level of sediment, generally as a result of soil erosion. Soil sealing reduces the natural infiltration of water into the soil, and thus exacerbates flood peaks.

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● Global Soil Week (Berlin)   ● Earth Day

No soil...
no habitat

MAY 2015

More than 25% of all living species are found in the soil. The total weight of soil organisms often equals or exceeds the aboveground visible biomass. A few hundred grammes of fertile soil can contain billions of bacteria, kilometres of fungal hyphae, tens of thousands of protozoa, thousands of nematodes, several hundred insects, arachnids and worms, and hundreds of metres of plant roots. The biota turns the soil into a biological engine. Living creatures are involved in most of the key soil functions, driving fundamental nutrient cycling processes, regulating plant communities, degrading pollutants and stabilising soil structure. In addition, soil supports aboveground ecosystems and biodiversity.

The photograph above shows the variety of soil-living organisms: myriapods, beetles, earthworms, fungi, mites, collembola, moles and nematodes.

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● Start of Expo Milano: Feeding the planet - Energy for life ● International Day for Biological Diversity

No soil...
no raw materials

JUNE 2015

Eric Van Ranst

Soil provides a range of raw materials such as clay, sands, minerals and peat. Clay is used for making bricks for construction, pottery items (e.g. earthenware), and was an early writing medium (clay tablets). Daub has been used for making walls of buildings for at least 6 000 years; it is still an important construction material in many parts of Africa and is becoming popular again as a low-impact, sustainable building technique. Due to their impermeable properties, mud bricks and clay are used as a barrier to stop water seeping away, which is why many ponds, canals and landfill sites are lined with clay. Sand and gravel deposits are commonly used in the construction industry as aggregates in concrete making, while sand is the principal ingredient in glass making and is also used in sand-blasting to clean buildings and in sandbags to stop flooding. Even medicines can be regarded as soil materials; penicillin, for example, the first antibiotic, is a soil-based fungus.

The photograph above shows an oven in Africa built from, and used to fire, bricks made from clay-rich soil extracted from an adjacent termite mound (partially excavated in the background). Finished bricks are stacked in the foreground.

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● European Commission Green Week: Nature - our health, our wealth, Brussels
● World Environment Day
● World Day to Combat Desertification

No soil...
no cultural heritage

JULY 2015

Much of the evidence of human heritage remains buried within the soil, awaiting discovery and study by archaeologists and palaeoecologists (scientists that study past environments and ecosystems). The degree of preservation depends very much on the local soil characteristics and conditions. Soils with extreme characteristics (e.g. very acidic, very alkaline or waterlogged with low levels of oxygen) have very little microbial activity and provide an ideal environment for preserving organic remains. Any disturbance of these environments, such as by drainage or ploughing, changes these conditions and leads to the rapid decay and loss of material. Archaeologists use these historical artefacts and the layers in which they are preserved to reconstruct the communities that produced them and the environments in which they lived. But to do this, the soil layers must remain undisturbed.

The photograph above shows an archaeological dig at a site of a third century battle between Germanic and Roman troops at Harzhorn in northern Germany. In many cases, material discovered in the soil is the only evidence of historical events or of how people lived.

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No soil...
no landscapes

AUGUST 2015

Stable, healthy and productive landscapes reflect underpinning soil characteristics that are essential for producing most of our food, for maintaining environmental functions, managing water quality and sustaining primary industries while supporting rural and urban communities. Many rural landscapes are under constant or increasing pressure. Acidification, salinity, erosion, invasive vegetation and over-exploitation of the land are seriously affecting the condition of our soils and challenging the communities and industries that depend on the land. Understanding soil characteristics is critical to ensuring the sustainable use and development of any landscape.

The photograph above shows the variety of vegetation patterns, soil types and land use in the Ngorongoro Conservation Area in Tanzania. It is important to realise that landscapes and their associated soils generally support multiple uses and environmental functions.

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No soil... no platform for construction

SEPTEMBER 2015

Another widely recognised function of soil is to provide the solid foundations for buildings, structures such as communication towers, street lights, fences, paths and roads. Foundations can either be shallow (where building loads are supported by soil close to the surface) or deep (within the subsoil if loads are greater). The preserved remains of foundations (e.g. post holes) provide some of the earliest evidence of building construction. The load-bearing capacity and stability of foundations depend on soil characteristics such as texture, structure, organic matter content, bulk density and porosity. Inadequate foundations or processes such as cryoturbation or churning soils such as Vertisols can cause structures to subside or even collapse.

The photograph above shows an example of a rubble trench foundation, where a shallow trench is filled with stones. In cold climates, such foundations must extend below the frost line where they can also help groundwater drain away. They are suitable in soils that have a capacity of more than 10 tonnes/m^2.

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No soil...
no global nutrient cycles

OCTOBER 2015


Joe Papp - Wikimedia Commons

Soils play a crucial role in a number of life-sustaining natural biological and chemical cycles. Soil stores, moderates the release of, and transforms nutrients and other elements, often into forms that are available to plants. The most well-known and important biogeochemical cycles include the carbon cycle, the nitrogen cycle, the oxygen cycle, the phosphorus cycle, the sulphur cycle, the water cycle and the mineral cycle. These substances are continuously recycled between the soil and plants, geological deposits, groundwater and the atmosphere. The intensity of these bio-geochemical exchanges (fluxes) varies from place to place and is regulated by soil characteristics, land use and climate. Decomposition and transformations by soil organisms (mostly at microscopic scales) are at the core of most nutrient cycles.

The photograph above shows a clover plant (Trifolium), a member of the leguminous pea family. While highly palatable to grazing livestock, clover can naturally fix nitrogen in the soil, thus reducing the need for synthetic fertilisers. Plants, such as soybeans and peanuts, contain a symbiotic bacteria called rhizobia within nodules in their root systems, which produces nitrogen compounds that help the plant grow. When the plant dies, the stored nitrogen is released, making it available to other plants. Clovers normally have three leaves - those with four are generally considered to bring good luck to the finder!

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🔵 World Food Day

🔴 Where food comes from!
JRC-FAO-ENSA Public Engagement Event, Expo Milano

🟢 JRC-ENSA Soil Awareness Conference
Expo Milano & JRC Ispra

No soil...
no mitigation of climate change

NOVEMBER 2015

Arwyn Jones

While climate is a recognised soil-forming factor, most people are unaware of the impact of soils on global climates. Soil plays a key role in the Earth's carbon cycle and, therefore, is an important factor in global climate models. Soil is the largest terrestrial pool of organic carbon, containing approximately 2 200 gigatonnes (Gt). This value is well above the combined total of carbon stored in the atmosphere (780 Gt) and in plants (575 Gt). Carbon is taken out of the atmosphere by plant photosynthesis, and about 60 Gt per year is incorporated into various types of soil organic matter such as surface litter, roots, and plant or microbial exudates. Humans increasingly influence the size of this pool. The thawing of organic-rich permafrost soils could lead to significant natural emissions of methane which, in turn, could further exacerbate climate change processes.

The photograph above shows a cutting face in a peat bog. Peat is an organic soil which develops when the decomposition of organic matter is reduced or stopped either due to high levels of water or low temperatures. Such soils are major carbon sinks. In many countries, peat is cut, dried and used as a fuel for heating.

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No soil... no food

DECEMBER 2015

Most likely the most recognised soil function is as the medium that supports food production (i.e. crops) to sustain and enhance human life. Arable farming (the cultivation of field crops) was the key development in the rise of sedentary human civilisation, whereby food surpluses could be used to support cultural, political and religious activities. While agriculture depends on climates, cultures, and technologies, it is primarily dependent on the condition and characteristics of soil. In many parts of the developed world, industrial agriculture is based on large-scale monocultures, which can lead to degraded soils that need the application of synthesised fertilisers to be productive. There is growing support for sustainable agriculture that underpins soil functions and enhances both aboveground and belowground biodiversity.

The photograph above shows empty shelves in a supermarket. While in Europe the increasing globalisation of supply chains means that food security is not an issue for most people, increasing demands from European markets can put pressure on the soils of developing countries. The collapse of soil functions is the primary cause of desertification and eventually famine. While often exacerbated by political issues, the catastrophic consequences of such events are clearly visible in the suffering of Ethiopia in the mid-1980s and the mass exodus from Ireland in the 19th century.

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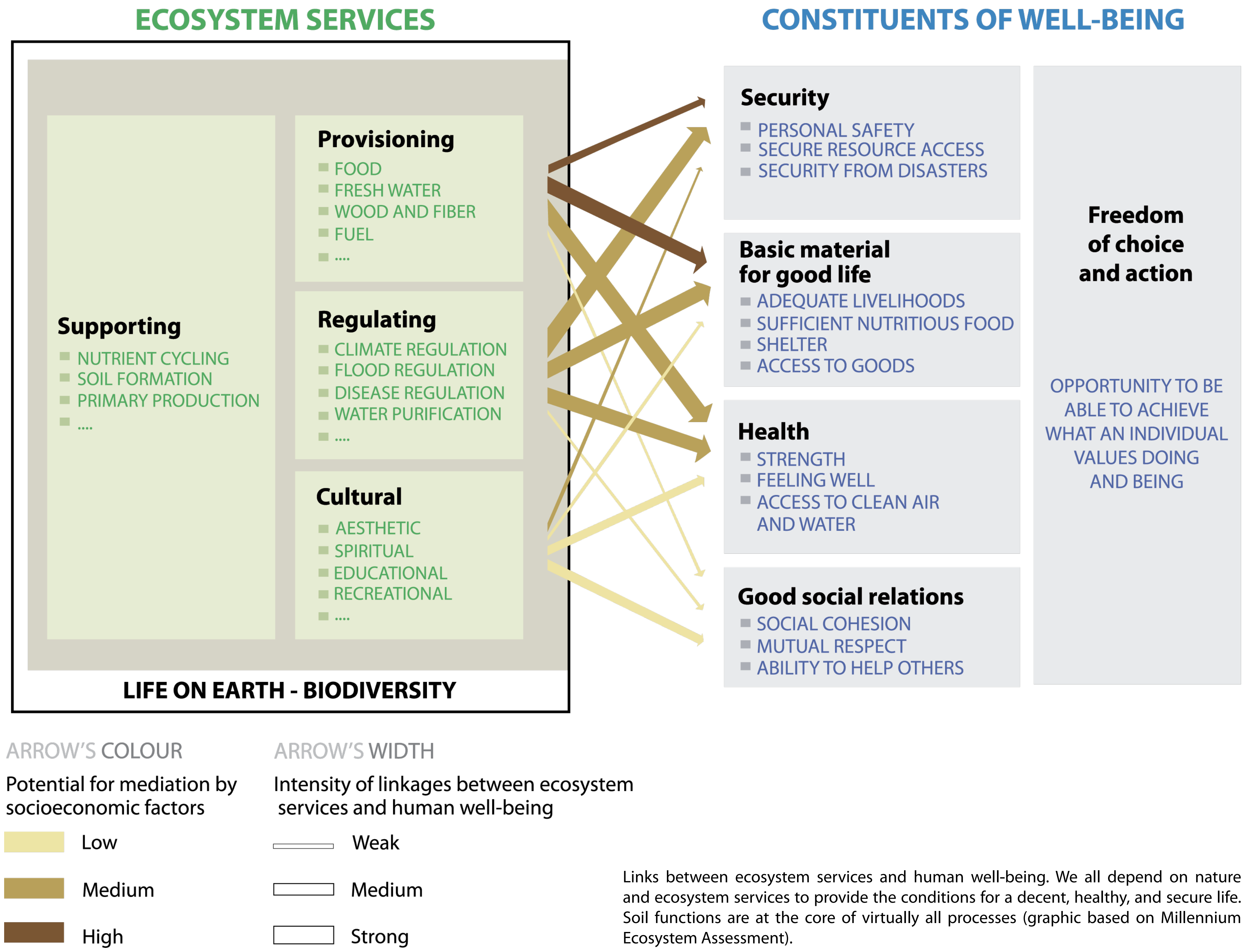
● World Soil Day

Key soil functions

While not widely appreciated by most people, soil is actually at the heart of nearly all terrestrial processes on which human and ecological well-being depends. Soil provides, regulates and supports a number of ecosystem services on which issues such as food security, the provision of shelter, access to goods, flood control, combating disease and cultural fulfilment all depend. Soil does all this by performing five essential functions.



Links between ecosystem services and human well-being. We all depend on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life. Soil functions are at the core of virtually all processes (graphic based on Millennium Ecosystem Assessment).

Growth Medium, Habitat and Biodiversity - Soil supports the growth of plants and is a habitat for animals and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat. The provision of food, fibre and fuel from terrestrial crops (including forestry) underpins human societies.

Nutrient cycling - Soil stores, controls the release of, and cycles nutrients and other essential elements. During these biogeochemical processes, which are analogous to the water cycle, nutrients can be transformed into forms that are easily available to plants, stored in the soil, or even released into air or water.

Water cycling - Soil can regulate the drainage, flow and storage of water and solutes. Soil partitions water for groundwater recharge and for use by plants and animals living in the soil. Soil sealing can destroy this capacity, leading to flood events which can cause significant damage and fatalities.

Filtering and buffering - Soil acts as a filter to protect the quality of water, air and other resources. Toxic compounds or excess nutrients can be trapped, degraded or otherwise made unavailable to plants and animals.

Support habitation and human health - Soil has the ability to maintain a porous structure that allows for the passage of air and water, can withstand erosive forces, and provides a medium for plant roots. Soils also provide anchoring support for human structures, and preserve archaeological treasures. While a healthy diet is critical to the well-being of both animals and humans, soils also support human health through the provision of several drugs; for example, antibiotics were originally synthesised from soil fungi and bacteria.

As with many soil characteristics, soil functions are difficult to measure directly, especially over large areas. Therefore, they are usually assessed by deriving indicators or proxies that correlate with soil conditions which can be used to assess how well the soil carries out a specific function. Some indicators are descriptive and can be used in the field (e.g. drainage is rapid), while others are more quantitative and must be assessed by laboratory analyses (e.g. pH, carbon content). There are three main categories of soil indicators: chemical (e.g. nutritional status), physical (e.g. hydrological characteristics, such as water retention) and biological (e.g. soil respiration). Organic matter transcends all three indicator categories as it is tied to all soil functions and is itself an indicator of soil quality.

Key threats to soil functions

Maintaining soil condition is essential for ensuring the sustainability of society. However, soil is under increasing threat from a wide range of human activities. These threats are complex and usually unevenly spread, but are frequently inter-linked. When many threats occur simultaneously, their combined effects tend to exacerbate the problem. Ultimately, if no measures are taken, soil will lose its capacity to carry out its functions. This process is known as soil degradation. The UNEP-funded GLASOD (Global Assessment of Human-induced Soil Degradation) project estimated that around 15% of the total land area of the planet is affected by some kind of human-induced degradation process. If non-productive land is discounted (i.e. desert, salt pans, lakes and mountains), then this figure is even higher. Key threats to soil functions include:

Loss of nutrients and/or organic matter occurs if agricultural activities are carried out on poor or moderately fertile soils without sufficient application of manure or fertiliser, which leads to soil depletion and eventually decreased production. Nutrients can also be lost after the clearing of natural vegetation. Such loss is becoming one of the most important pressures on soil, as it affects food security. If left unchecked, it can lead to a failure of the soil system and trigger the onset of desertification and social upheaval.

When soil degradation occurs in dry areas, it is known as **desertification**. The main drivers are climatic conditions (droughts, aridity, irregular and intense precipitation regimes) together with human activity (deforestation, overgrazing, soil structure deterioration). Affected land can no longer support vegetation. Desertification has extremely serious socio-economic consequences and can ultimately cause the destabilisation of societies and the mass migration of human populations.

Climate change presents an overarching but as yet uncertain factor that can amplify degradation processes.

Soil sealing occurs mainly through the development of technical, social and economic infrastructures, especially in urban areas.

Erosion occurs mainly due to the inappropriate use of soil for agriculture and forestry, but also as a result of uncontrolled building development and water runoff from roads and other sealed surfaces.

Decline in biodiversity is linked to the **loss of organic matter**, because all soil biota depend on organic matter. There is only limited information on this aspect.

Contamination occurs due to a range of human activities, such as industrial production, traffic, the use of fossil material, such as ores, oil, coal and salts, or agricultural activities. It can be diffuse (widespread) or localised. Local contamination can give rise to major health issues, and is usually associated with industrial production.

Compaction and the further physical deterioration of subsoils is a relatively new phenomenon caused mainly by high pressures put on soil by heavily loaded vehicles used in agriculture, forest and other land use activities. This is also a problem in areas with dense animal stocks.

Hydro-geological risks are complex phenomena that lead to floods and landslides, partly as a result of inappropriate soil and land uses (e.g. sealing, compaction, land use change) as well as uncontrolled mining activities.

Salinisation is a problem in agricultural areas where saline groundwater or inappropriate irrigation practices lead to an accumulation of salts in the soil, which in turn affects plant growth and crop yields.


Dirk Beyer, Wikimedia Commons


Jasvipul Chawla, Wikimedia Commons


Barak Okoba


Philippe Mayaux


Cezary Piwowarski, Wikimedia Commons


J. L. Rajot, IRD

European Commission

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The authors of this calendar, Arwyn Jones, Martha B. Dunbar, Alberto Orgiazzi, Agnieszka Romanowicz, Ana Paya-Perez, Gráinne Mulhern, Gergely Toth and Luca Montanarella gratefully acknowledge all contributions.

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