

SUMMARY OF THE STATE OF **SOILS IN FIVE COUNTRIES**

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Foreword

This report is the third in a series published by ISWA's Working Group on the Biological Treatment of Waste (WGBTW). It forms part of a desk-top research project investigating the linkages between organic waste arisings, their treatment for recycling and the benefits of applying compost and anaerobic digestate to soil.

The purpose of this report is to highlight the main threats to, and diversity of, soil in different parts of the world. It is not intended to be a comprehensive treatise; but instead provides a brief summary that can be understood and used by urban planners, waste planners and managers. Its aim is to highlight the importance of considering land use and soil quality, and its links with food production, organic waste and quality compost and digestate.

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Executive summary

Soil is the source of almost all of the world's food, grown either directly as crops, or indirectly as land-based animals. However, it has been estimated that 80% of the world's agricultural land suffers moderate to severe erosion, with 100'000 km² of agricultural land being lost through soil erosion every year. Over the last 40 years, about 30% of the world's cropland has become unproductive, with the loss of soil organic matter cited as a major contributor. This has obvious implications for food security, as well as having detrimental effects on the climate and water management caused by the loss of soil carbon.

This report summarises the status and threats to soils in different regions of the world. Countries representative of different geographic, climatic and socio-economic regions, were chosen as the threats to soil are a function of both natural and man-made factors. The regions are:

Oceania
(Australia)

South America
(Brazil and Chile)

Mediterranean Europe
(Italy)

Northern Europe
(United Kingdom)

Of all the five countries studied, it was found that none have in place national legislation protecting and enhancing soil; however, specific initiatives, policy documents and legislation could be found at the regional level.

On the other hand, all five countries were also shown to suffer from soil erosion and loss of soil organic matter. The main threats to soil for each country include:

- **Australia** - Extensive agricultural practises, settlement of the continent starting from 1788;
- **Brazil** - Deforestation, unsustainable land use practices and tropical climate;
- **Chile** - Climate change and unsustainable land use practices;
- **Italy** - Changes in forestry and permanent pastureland;
- **United Kingdom** - Intensive agricultural practices.

All five countries studied suggested that agricultural productivity was being adversely affected due to soil degradation. Chile was the worst affected, having a decrease in agricultural productivity of just over 30%, with 93% of communes being adversely affected by desertification processes; whilst in the UK, the Committee on Climate Change suggested that "Some of the most productive agricultural land in England is at risk of becoming unprofitable within a generation due to soil erosion and the loss of organic carbon".

The combined effects of climate change and unsustainable land use practices is, therefore, eroding soils at an unsustainable rate, threatening food security globally. The protection and enhancement of soils necessarily requires a multi-faceted approach

involving, *inter alia*, changing land use and agricultural practices. This needs to be underpinned by legislation that is enforced effectively.

In all five countries, erosion and loss of organic matter could potentially be reduced through the application of high-quality compost to soil. A tentative correlation between the area of degraded land in each of the five countries, and the amounts of compost needed, at a minimum, to improve the organic matter content in soil was estimated. The results suggest that not a single country reviewed in this study would be able to either halt or reverse degradation if they were to rely solely on compost production by municipalities. However, in the two European countries assessed (IT and UK), the contribution made by adding compost to degraded soil could be significant. Other than Australia, the remaining countries could, in theory, improve significant areas of degraded soil by applying quality compost annually.

The challenge is therefore, to link the separate collection of organic wastes (especially in cities), its treatment and the production of quality soil improvers back onto agricultural land on which food is grown. More generally speaking, an holistic approach to achieve soil protection and enhancement should focus on closer teamwork between the initiatives of the circular economy applied to the recycling of organic waste and initiatives to restore the content of organic carbon in soils. Without this circularity, it seems likely that our soil's ability to remain productive diminishes year-on-year; coupled with a growing global population, this urgently needs addressing.

The combined effects of climate change and unsustainable land use practices is eroding soils at an unsustainable rate, threatening food security globally. **The protection and enhancement of soils necessarily requires a multi-faceted approach.**

Introduction

Soil is the source of almost all of the world's food, grown either directly as crops, or indirectly as land-based animals. However, this process is hugely inefficient, with about one-third thought to be lost during harvest and transportation or wasted by retailers and consumers¹. In addition, by 2050, the world will need to produce double the amount of food it currently does, but using less water and soil, assuming that current degradation trends continue².

ISWA has recently estimated in its Report 'Global Assessment of Municipal Organic Waste' that just under one billion tonnes of organic waste is produced annually, equivalent to about 0.35 kg / capita / day³ - a significant proportion of which is food waste. The minimisation of food waste has received much attention recently, even though it continues to be generated in huge quantities.

Currently, in many parts of the world, this organic waste is not managed in an 'environmentally safe manner', leading to the generation of odours, vermin and methane. This represents both a public health hazard caused by poor municipal solid waste (MSW) management practises and a climate change challenge. A rising global population, coupled with increasing urbanisation and consumerism is leading to concentration of these organic wastes in cities; the anticipated rise in mega cities (i.e. cities having populations over 10 million inhabitants) presents further challenges for urban planners, as the link between food production and its consumption becomes increasingly disconnected.

Separately collected organic wastes can be treated through either composting and/or anaerobic digestion processes and converted into useful products, such as compost and anaerobic digestate. The benefits of these products have been known about for centuries, and ISWA has recently published a summary of some of the beneficial effects they have on soil⁴.

Despite the obvious potential to transform unavoidable organic waste into compost and digestate, the health of the soil from which they are derived is under threat. It has been estimated that 80% of the world's agricultural land suffers moderate to severe erosion, with 100'000 km² of agricultural land being lost through soil erosion every year. Over the last 40 years, about 30% of the world's cropland has become unproductive, with the loss of soil organic matter cited as a major contributor⁵. This has obvious implications for food security, as well as having detrimental effects on the climate and water management caused by the loss of soil carbon.

¹ FAO. 2011. Global food losses and food waste – Extent, causes and prevention. Rome

² Campbell A (2008) Managing Australia's Soils: A Policy Discussion Paper. Prepared for the National Committee on Soil and Terrain (NCST) through the Natural Resource Management Ministerial Council (NRMMC).

³ Ricci-Jürgensen *et al.* (2020) Global Assessment of Municipal Organic Waste Production and Recycling. ISWA, Rotterdam.

⁴ Gilbert *et al.* (2020) Benefits of Compost and Anaerobic Digestate When Applied to Soil. ISWA, Rotterdam.

⁵ Pimentell & Burgess (2013) Soil Erosion Threatens Food Production. *Agriculture* 3: 443-463.

The purpose of this report is to highlight the status and threats to soils in different regions of the world. Countries representative of different geographic, climatic and socio-economic regions, where the threats to soil are a function of both natural and man-made factors. The regions and countries studied were:



Oceania
(Australia)



South America
(Brazil and Chile)



Mediterranean Europe
(Italy)



Northern Europe
(United Kingdom)

This report is a non-technical document that has been written in such a way that it can be read and understood by professionals and interested stakeholders who do not have a background in soil science. Its aim is to prompt discussion and strategic thought about the vital link between treating organic wastes and applying quality products, such as compost, back onto soil.



5 National assessments

The following section summarises the status of soils and how they are protected in five different countries, falling in different geographic regions.

The key data referring to the countries are shown in Table 1; although the data presented here may differ slightly from those quoted in the country overviews due to the reference sources used.

Table 1 - Countries by population, population density and land use

Country	Population (Rounded To The Nearest Million)	Population Density (capita/km²)	Fraction Of Surface Area Used For Urban & Developed Areas
Australia	25	3	4.0%
Brazil	211	25	0.6%
Chile	19	25	1.6%
Italy	61	201	7.7%
United Kingdom	68	278	11.7%

Source: retrieved 2019-11-13, from <http://worldpopulationreview.com/countries/countries-by-density/>

5.1

Australia

Australia is located in Oceania in the Southern Hemisphere. It consists of mainland Australia, the island state of Tasmania, and over eight thousand smaller islands, and is surrounded by the Pacific and Indian Oceans. It is a large country, but only has a relatively small population of 25.5 million inhabitants, with the majority of the population living on the east coast in urban conurbations. Sydney, in New South Wales, is the most populated city.

The country has a diverse range of habitats and climates, ranging from tropical rainforest in the north, through humid sub-tropical in the south east, to hot desert among most of its centre and western land mass. Australia has a unique flora and fauna, characterised by evergreen Eucalyptus trees and marsupial animals.

5.1.1

Legislation

Australia is a federation of eight states and according to the Australian Constitution⁶, each jurisdiction has responsibility for land use policy and planning. The Australian Government plays a major role or takes the lead in developing partnerships between key national, state and regional stakeholders. Administration of soil-related activities—including land management, soil monitoring and mapping, planning and delivery of extension services—are the responsibility of the states and territories, under various legislation.

In 2009, the Government established the Soil Carbon Research Program which includes among its targets to develop and implement a nationally consistent approach to quantifying soil organic carbon stocks under combinations of major land-use and management regimes, climate, and soil types used for agricultural production in Australia⁷.

According to the National Soil Research, Development and Extension Strategy⁸ (NSRDES) released in 2014, the agricultural sector and industry “will be expected to manage soil to store more carbon and to reduce its greenhouse gas emissions, such as those associated with fertiliser use” since public opinion in Australia “expect production of food and fibre products to be sustainable and with agricultural landscapes to provide ... healthy soils”.

The National Landcare Program⁹ is a nationwide effort started in 2014-15 to address soil degradation and loss of vegetation by supporting locally focussed initiatives and projects for protecting and restoring the environment and making agriculture more sustainable and productive contributing to greenhouse gas mitigation. The Government is investing AU\$1 billion (EURO 620 million) through the Program over four years.

The Emissions Reduction Fund is distributing¹⁰ in 2017 more than AU\$225 million (EURO 140 million) as a new income stream for farmers and land managers and carbon service providers, including activities for farmers and land managers to store soil in carbon¹¹.

5.1.2

Land use in Australia – extent of the issue

Australia comprises a land area of almost 7.7 million square kilometres, with just under 64% used to meet domestic food and fibre needs, and to provide export income. Less than 4% of the total land area is under intensive agricultural and urban use.

5.1.3

Specific threats to Australian soils



Australian soil experienced a sharp change in a relatively short time period (since the continent was settled and developed between 1788 and 1950); today around 57% of the land area has been modified for agricultural and pastoral use¹², with 82% of this being used to graze livestock¹³. Soil salinity and acidification of land cleared of native vegetation for agriculture therefore creates challenges for policy makers.

Australian soils generally have a low organic matter content¹⁴. This is compounded in parts of the country by inherently low levels of soil fertility, and variable amounts of rainfall. The State of the Environment surveys and other reports have shown that soil degradation, including acidification, erosion and loss of soil carbon, will increasingly affect Australia’s agriculture unless carefully managed⁸.

Organic matter: Across Australia, it has been estimated that in 2010 the total organic carbon stock amounted to 25 Pg in the top 0–30 cm¹⁴. However, in about one third of soils, the carbon content is classed as either ‘poor’ or ‘very poor’, especially regions with cropping and/or intensively managed grazing systems (approximately 75 million hectares)⁸.

Salinity: This is one of Australia’s most costly forms of land degradation according to a national assessment conducted in 2001; with dryland salinity being expected to rise from 5.7 million hectares to 17 million hectares by 2050¹⁵.

Acidity: This is thought to particularly affect soil in Western Australia used to grow wheat⁸, and it is thought to affect about 50% of agricultural land, primarily in Western Australia and New South Wales¹⁵.

Soil erosion: This is caused by wind and water, and is thought to affect just over 50% of these areas, with erosion rates over ten times greater than the rate of soil formation¹⁶.

From an economic perspective, Australian soils are thought to directly contribute an estimated AUD 63 million (EURO 39 million) a year to the economy¹⁷.

⁶ <http://press-files.anu.edu.au/downloads/press/n4113/html/ch01.xhtml?referer=&page=9#>

⁷ <https://soe.environment.gov.au/theme/land/topic/soil-carbon-dynamics>

⁸ Securing Australia’s Soil, For Profitable Industries and Healthy Landscapes (2014), The National Soil Research, Development and Extension Strategy

⁹ <http://www.nrm.gov.au/national-landcare-program>

¹⁰ According to an estimation by the Australian Farm Institute.

¹¹ <http://www.environment.gov.au/climate-change/farmers-and-land-managers>

¹² <http://press-files.anu.edu.au/downloads/press/n4113/html/ch01.xhtml?referer=&page=9#>

¹³ <https://soe.environment.gov.au/theme/land/topic/2016/contemporary-land-use-pressures>

¹⁴ <https://soe.environment.gov.au/theme/land/topic/soil-carbon-dynamics>

¹⁵ <https://soe.environment.gov.au/theme/land/topic/2016/soil-salinity-and-acidification>

¹⁶ <https://soe.environment.gov.au/theme/land/topic/2016/soil-formation-and-erosion>

¹⁷ Save Our Soils Supporting Document (2019) Soil Science Australia. Downloaded from: www.soilscienceaustralia.org.au/wp-content/uploads/2019/12/SOS-support-document.pdf

Key data

Australia comprises a land area of almost 7.7 million square kilometres, with just under 64% used to meet domestic food and fibre needs, and to provide export income. Less than 4% of the total land area is under intensive agricultural and urban use.

Surface area of Australia

7'700'000 km²

Agricultural surface area in use

4'928'000 km²

Grazing native vegetation

3'559'000 km²

Use of soil (urban & developed land)

308'000 km²

Maps and figures

Figure 1 – Land use in Australia – 2005-2006

Source: <http://press-files.anu.edu.au/downloads/press/n4113/html/ch03.xhtml>

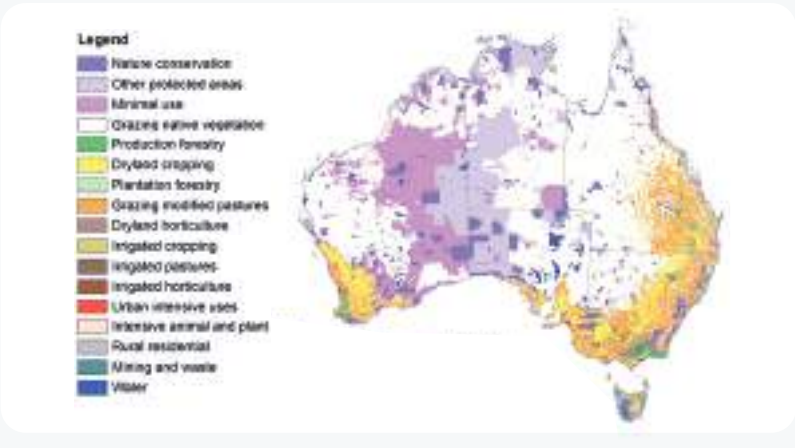


Figure 2 – State and trends in SOC in Australia – 2011

Source: <https://soe.environment.gov.au/theme/land/topic/soil-carbon-dynamics>

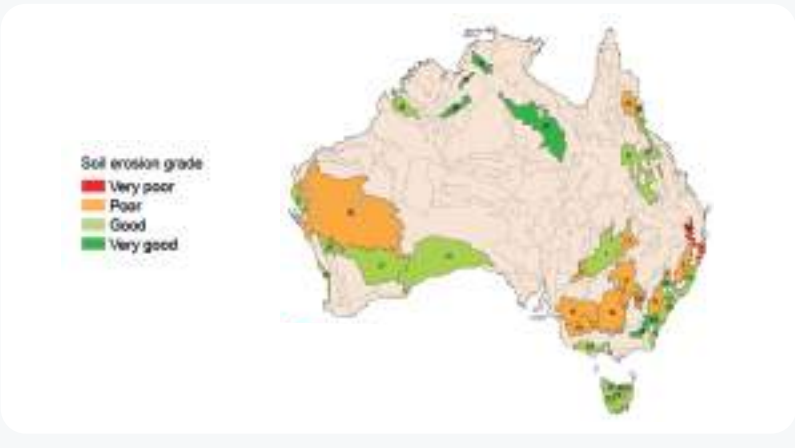


Figure 3 – Soil erosion by wind and water across Australia – 2011

Source: <https://soe.environment.gov.au/assessment-summary/land/state-and-trends-soil-erosion-water-and-wind>



Brazil

Brazil is located in South America and borders the Atlantic Ocean on its eastern side. It is a large country, having a population of about 211 million, with over 80% living in urban areas; the most populous city being São Paulo. It has an approximate population density of 25/km².

The country has a diverse range of habitats and climates, ranging from tropical rainforest in the north, to sub-tropical in the south. It is highly biodiverse and includes the Amazon River basin and its associated tropical forests.

Legislation

In Brazil, there is no specific national legislation to address soil use and/or protection, although policies may exist at the state and municipal level under specific conditions.

Nonetheless, the National Forest Code (revised in 2012) is the major legal tool to address soil and vegetation protection. The Forest Code (law number 12.651 of 2012) declared areas around rivers, lagoons (natural and artificial), springs, slopes of more than 45°, mangroves, sandbanks, mountains over 1800 meters above sea level, wetlands and others as being permanently protected. Furthermore, the law also instituted that farmers should conserve native vegetation in Legal Reserves, beyond permanently protected areas. The extent of a Legal Reserve depends on a farmer's area varying from 20% to 80% in the Amazon area (depending on local vegetation) and 20% in other areas. In these areas, only sustainable practices are allowed, such as agroforestry and the extraction of natural resources etc.

To address land use planning in 2015, Brazil launched a project to map the use of soil, called the PronaSolos. The PronaSolos¹⁸ National Programme will map soils of the Brazilian territory up to 2048, at scales from 1:25'000 to 1:100'000. Nowadays, only large-scale maps are available, in contrast to higher definition maps found in developed countries. The Brazilian government estimates that the investment is in the order of R\$ 4 billion¹⁹ (EURO 880 million) over 30 years. The return of the investment to society can reach R\$ 185 for each R\$ 1 spent.

¹⁸ <https://www.embrapa.br/pronasolos>.

¹⁹ 1 USD = 4,14 BRL at 02.10.2019.



Land use in Brazil - extent of the issue

Land use for artificial areas accounts for only 0.6%²⁰ (51'065 km²) of 8'510'820 square kilometres from national territory²¹. Around 60.3% of the land area is forest, 29.6% agricultural lands, 7.5% natural non-forest land and 2% water. From the agricultural land, 69% is dedicated to livestock grazing, 24% for growing crops and 7% for mixed use²⁰

According to MapBiomass²⁰, Brazil lost 890'000 km² of its native vegetation, meanwhile grazing land raised 37% and agriculture 150% from 1985 to 2018.



Specific threats to Brazilian soils

Soil Erosion: Studies estimate that Brazil loses around 800 million metric tonnes per year due to water erosion of soil. This might rise by 20% by 2023 if future agricultural expansion results in deforestation. Nonetheless, soil erosion could be reduced by 20% if this expansion utilises degraded pasture²².

Organic matter in soils: Organic carbon stocks in Brazilian soils in the top 0 to 30 cm account for around 36,3 Pg²³. Most areas have a concentration of between 0.49 to 41 kg of carbon per m², a relatively low concentration compared to temperate areas. This is a major threat to tropical agriculture in Brazil²⁴, as Brazil adopts unsustainable land use practices. Practices such as soil tillage, the absence of soil cover/mulching and monoculture rapidly destroy natural organic matter due to the tropical conditions (including intense rainfall and high temperatures) which cause lower productivity and higher demand of synthetic fertilisers that leads to water pollution.

Nutrient loss and land degradation: The Ministry of Environment estimate that 300'000 km² of pastures are degraded in Brazil²⁵. This number does not account for degraded urban land and soy/corn and other commercial agricultural commodities grown on degraded lands. Furthermore, the last study about desertification in Brazil indicated that around 180'000 km² of land is already classed as being in severe and extreme severe desertification process in Brazil, all of these areas in the north east of the country, which includes the poorest areas in Brazil²⁶.

Key data - Baseline year: 2018

Surface area of Brazil	Agricultural surface area in use	Use of soil (urban & developed land)
8'510'820 km²	2'519'203 km²	51'065 km²

²⁰ <https://mapbiomas.org/>
²¹ <https://cidades.ibge.gov.br/brasil/panorama>
²² Merten, G. H., & Minella, J. P. (2013). The expansion of Brazilian agriculture: soil erosion scenarios. International Soil and Water Conservation Research, 1(3), 37-48
²³ <https://www.embrapa.br/busca-de-noticias/-/noticia/30179699/brasil-lanca-o-mapa-de-carbono-organico-do-solo>.
²⁴ Primavesi, A. (2017). Manejo ecológico do solo: a agricultura em regiões tropicais. Nobel Editora.
²⁵ www.mma.gov.br/destaques/item/8705-recupera%C3%A7%C3%A3o-de-%C3%A1reas-degradadas
²⁶ Atlas das áreas susceptíveis à desertificação do Brasil / MMA, Secretaria de Recursos Hídricos, Universidade Federal da Paraíba; Marcos Oliveira Santana, organizador. Brasília: MMA, 2007

Maps and figures

Figure 4 – Soil use and statistics in Brazil.

Source: <https://mapbiomas.org/>

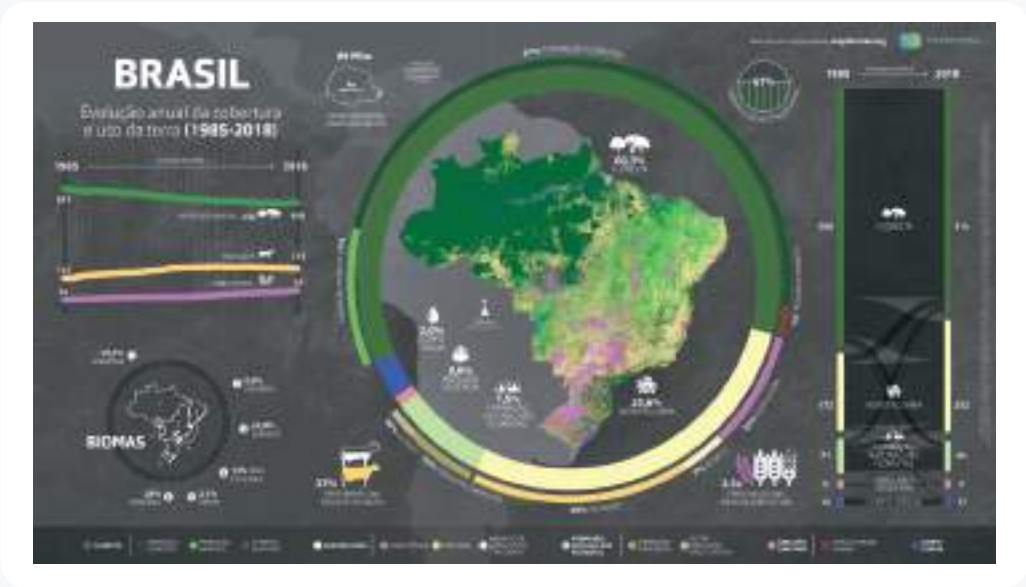
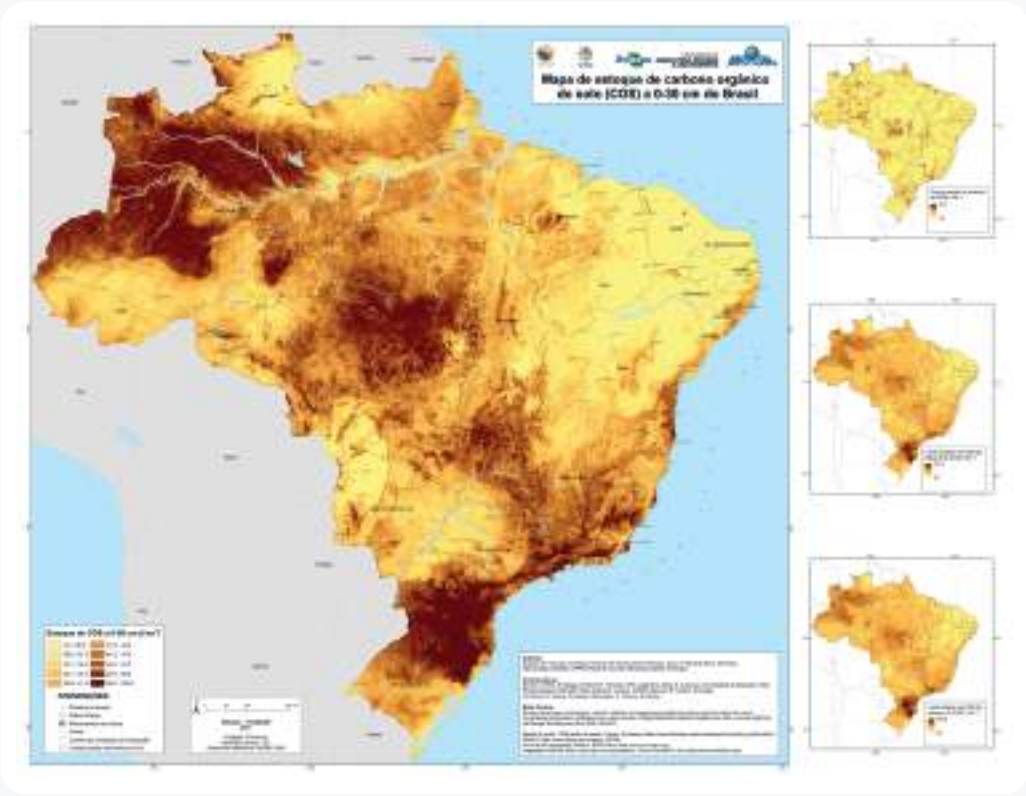


Figure 5 – Organic carbon stocks in Brazilian soils at 0 – 30 cm in 2017

Source: Source: <http://geoinfo.cnps.embrapa.br/documents/111527>



²⁷ Further information can be found at: <https://www.embrapa.br/solos/busca-de-publicacoes/-/publicacao/1085127/soil-organic-carbon-stock-at-0-30-cm-map-forbrazil-technical-report>

Chile

Chile is located in South America. It is a long, thin country bordering the Pacific Ocean on its western side and the Andes mountain range on its eastern side. It has a population of about 19 million, with approximately 85% living in urban areas; the most populous city being Santiago.

Due to its great length (over 4'000 km), Chile has a diverse climate, ranging from the very arid Atacama Desert in the north, through a Mediterranean climate in the centre, to an oceanic climate in the south.

Legislation

In Chile, territorial planning is still developing²⁸, because there are no norms, instruments, institutions and procedures that fully regulate occupation of the territory at the regional or communal level, much less at the national level. The regulation of land use in Chile is carried out within the framework of municipal legislation through 'territorial planning instruments'; however, in urban legislation the land is present as long as it allows subdivision, building and urbanisation, but not for its characteristics or value.

There is also no legal framework developed for soil protection in Chile. From the point of view of regulations²⁹, only one regulation is available for the management of sludge generated in wastewater treatment plants (norm 1007456). This regulation establishes the maximum concentration of different heavy metals in the receiving soil, but there is no regulation that establishes the maximum concentration of a contaminant (organic or inorganic) in a soil, from which type of soil must be subjected to a remediation process.

²⁸ Dra. Sonia Reyes Paecke, Suelo y Ordenamiento Territorial, Pontificia Universidad Católica de Chile, Seminario Ley General de Suelos June 2019

²⁹ Dr. Mauricio Escudey, Contaminación de Suelos, Universidad de Santiago de Chile, Seminario Ley General de Suelos June 2019



Land use in Chile – extent of the issue

The total area of continental Chile is 756'000 km². An important part of this area consists of unproductive soils, from an agricultural and forestry point of view (deserts, ice fields and inland waters). The productive land represents about 460'000 km², that is, 61% of the continental territory³⁰. The total area sown or planted in Chile, according to the 2007 agricultural census is 298'000 km². Finally, approximately 160'000 km² are native forest soils and wetlands.

With a land availability of 0.26 hectares per inhabitant (2'600 m²/inhabitant), Chile is not far from reaching the land shortage line, set at 0.20 hectares per inhabitant³¹. If the current rate of loss of agricultural land was maintained, along with the obvious advance of the desert at a rate of the order of 0.5 km per year, Chile would be crossing this line in about 30 years' time, which would seriously impact the planned increase in exports of agricultural products. Only in the last ten years there has been a significant increase in residential and industrial areas, which in the central valley occupies the most fertile agricultural land, while there is a decrease of the areas covered by snow and glaciers and the bodies of water and the prairies, scrublands and agricultural land.



Specific threats to soils

Between 60% to 65% of the arable land in the country is on soils derived from volcanic material³². Among the most significant volcanic soils are the so-called Trumaos (or Andisols), characterized by high productivity. Thus, whilst the Andisols represent less than 1% of the soils worldwide, they are responsible for sustaining 10% of the planet's population. While on the one hand a significant fraction of the soils in Chile have water problems, on the other hand we have a country that is an important area having soils with the highest quality and productivity, a condition that must be preserved for future generations and to guarantee the well-being of the population.

If we focus of the productive lands, about three quarters, that is, 345'000 km², suffer some degree of erosion. Of this area, 66%, or 228'000 km², are affected by moderate to mild levels of erosion and 34% have severe to very severe erosion levels, which means that they have lost between 60% and 100% of soil depth suitable for cultivation³³.

The global desertification process would be affecting an approximate area of 473'000 km², which is equivalent to 62.3% of the national territory. According to antecedents of the 'Preliminary Map of Desertification in Chile' (CONAF, 1999), where 290 communes were analysed, 93% of these would be affected in

different degrees by desertification processes, the rest (7%) do not show active signs.

According to experts, it is estimated that the desert will advance from 0.4 to 1 km per year, having as its main causes the natural climatic changes that accentuate the aridity of the territory, as well as inadequate and persistent human activities, overgrazing, repeated breaking of the soil that leads to depletion of fertility, oxidation of organic matter and erosion. The consequences of the above have been a 32% decrease in agricultural productivity in less than 10 years, migration and droughts, amongst others.



³⁰ "La Desertificación en Chile" Unidad de Diagnóstico Parlamentario, 2012.

³¹ Dr. Fernando Santibañez, Uso de Suelo y Cambio Climático, Universidad de Chile, Seminario Ley General de Suelos June 2019

³² Dr. Mauricio Escudey

³³ "La Desertificación en Chile" Unidad de Diagnóstico Parlamentario, 2012, Carlos Rodríguez Ormazabal y Maryan Henríquez

5.3.4

Key data - Baseline years: 2017/18; urban land use 2010

Surface area of Chile	Agricultural surface area in use	Use of soil (urban & developed land):
756'000 km ²	460'000 km ²	12'028 km ²

5.3.5

Maps and figures

Figure 6 – Critical land use of areas in Chile

Source: La Desertification in Chile, 2012

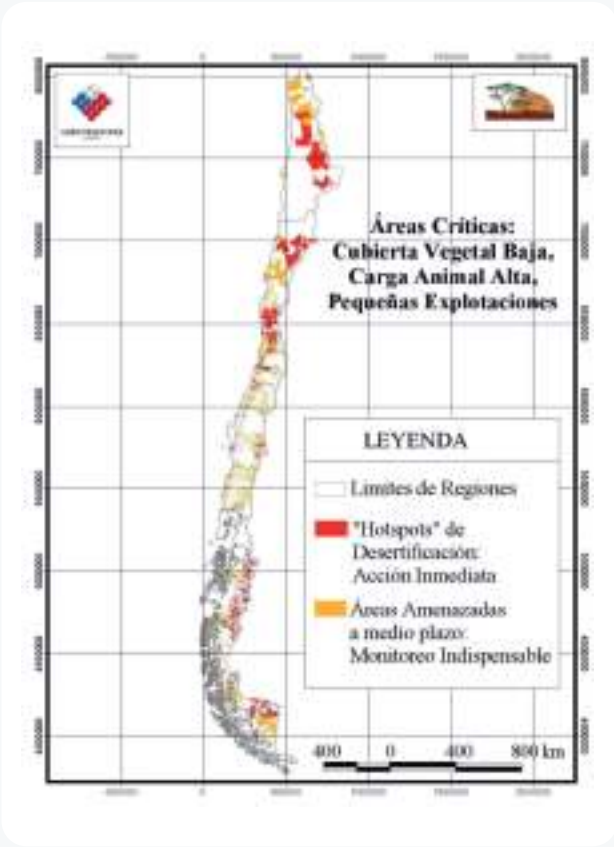
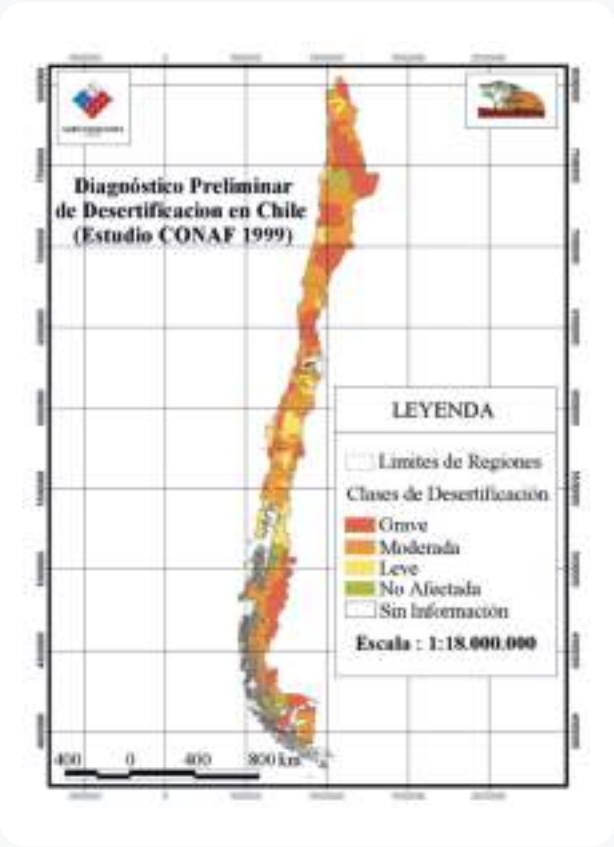


Figure 7 – Desertification of areas in Chile

Source: La Desertification in Chile, 2012



5.4

Italy

Italy is a long boot-shaped peninsular located in southern Europe. It is a mountainous country, having the Apennine Mountains stretching for over 1'000 km along its centre and bordering the Alps on its northern side. To the east is the Adriatic Sea, and the Mediterranean Sea on its south and western sides.

Italy has a population of about 61 million, with approximately 70% living in urban areas; the most populous cities being Rome and Milan. Due to its length (over 1'000 km) and location, it has a Mediterranean climate in the south, and a humid subtropical climate in the north.



5.4.1

Legislation

In 2018 Italy issued the National Map for organic carbon in soils, as part of its commitment to the FAO Global Soil Partnership³⁴.

There are different scenarios highlighted by ISPRA³⁵, the Italian Agency of the Ministry of Environment, which estimates that land use will increase between 1672 km² and 7064 km² (according to different scenarios) by 2050 compared to the baseline year 2017.

No specific national legislation has currently been adopted in Italy with the aim of protecting soil and reducing land cover in the medium and long term according to the action and targets proposed by the European Commission in its policy report (COM(2012) 46), even though draft legislation was prepared in 2016.

Various Italian Regions have adopted between 2013-2017 local legislation to reduce the use of soil, limit land cover and recover soil in urbanised areas. Legislation adopted in regions such as Lombardy, Veneto and others include zero-cover of new land by 2050. Based on the EU agricultural policy, many Italian regions are currently planning specific measures – to come into force between 2021-2027 – such as conservation agricultural practices and no-tillage but currently there are no dedicated initiatives regarding the use of organic fertilisers.

³⁴ www.fao.org/global-soil-partnership/en/

³⁵ ISPRA, Rapporto Consumo Suolo 2018, Italy

³⁶ See previous footnote

5.4.2

Land use in Italy - extent of the issue

The land cover in 2017 in Italy³⁶ is about 23'063 km² or 7.7% of the total Italian territory; between 2016/2017 soil use increased at 52 km²/year, a relatively low value that dropped in the last decade due to the economic situation in Italy and which includes the amounts of land recovered.

About 56% of the increase of land cover between 2016/2017 was on former agricultural land and in the 74 main urban areas the changes in land cover between 2012-2017 were mainly on former agricultural areas.

ISPRA estimates that between 2012 and 2017 the loss of ecosystem services - due to use of soils – accounts on average for EURO 1.9 billion a year; about 88% of this value is due to the loss of water regulatory capacity, followed by agricultural production and erosion protection.

The value of natural capital lost due to soil use between 2012 and 2017 has been estimated at between EURO 0.91 billion and 1.1 billion, an average of EURO 39'100 per hectare of soil used; about 80% of this value was due to the loss of agricultural production. Thus, the use (and loss) of soil in Italy determines a loss of soil function (i.e. agricultural production) and basic environmental services (i.e. water holding capacity and acting as a carbon sink).





5.4.3

Specific threads to Italian soils

Soil erosion: In many areas of Italy erosion by water exceeds 8.8 tonnes hectare⁻¹ year⁻¹, with 29% of arable land having losses greater than 10 t ha⁻¹ yr⁻¹; approximately 73% of soil erosion occurs in 25% of cropland³⁷.

Organic matter in soils: The estimated soil organic carbon stocks in Italy accounts for 2'800 million tonnes, and national assessments estimate that 86% of soils have a low organic carbon content (i.e. below 2%), which falls in the pre-desertification range³⁸. Topsoil organic matter in Italy is lost due to changes in forestry and permanent pastureland. Thus 10% of Italy's territory has a high sensitivity

to desertification, and 49% has a medium sensitivity. In particular, 70% of Sicily's soils have a medium or a high degree of environmental vulnerability³⁹. According to the World Atlas of Desertification this has caused a constant decline in the productive capacity of Italian soils in the last 25 years⁴⁰.

An assessment by the European Commission's Institute for Environment and Sustainability, suggested that if Good Agricultural and Environmental Conditions (GAEC) were fully adopted in Italy, soil erosion could be reduced in the long-term by 43% and soil organic carbon stocks would increase by 11%⁴¹.

Soil sealing: According to Eurostat data⁴² for 2015, Italy's land coverage by artificial areas⁴³ accounts for 6.9% and exceeds by 64% the EU average (4.2%). Among 39 European countries Italy registers⁴⁴ between 2009-2012 the third largest increase in soil sealing (0.05% annually). Soil sealing is amplified by increasing urban sprawl, which is characterized by low-density urban expansion that tends to occupy horizontally vast shares of territory, thus increasing the amount of urban areas that may undergo sealing processes⁴⁵.



An assessment by the European Commission's Institute for Environment and Sustainability, suggested that if Good Agricultural and Environmental Conditions (GAEC) were fully adopted in Italy, **soil erosion could be reduced in the long-term by 43%**

5.4.4

Key data - Baseline years: 2017/18

Surface area of Italy	Agricultural surface area in use	Land cover
301'338 km ²	127'000 km ²	23'063 km ²

³⁷ Effect of Good Agricultural and Environmental Conditions on erosion and soil organic carbon balance: A national case study, Borrelli *et al.*, 2016

³⁸ Organic Matter in the soils of Europe: Present status and future trends, Rusco, Jones, Bidoglio, 2001.

³⁹ Combating desertification in the EU: a growing threat in need of more action, European Court of Auditors, 2018.

⁴⁰ <http://wad.jrc.ec.europa.eu>.

⁴¹ Effect of Good Agricultural and Environmental Conditions on erosion and soil organic carbon balance: A national case study, Borrelli *et al.*, 2016

⁴² <https://ogy.de/wfu3>

⁴³ According to Eurostat "Artificial areas are those characterised by an artificial and often impervious cover of constructions and pavement".

⁴⁴ Aggregated Imperviousness change information 2009-2012, European Environment Agency (EEA), https://www.eea.europa.eu/data-and-maps/daviz/annual-average-sealing-increase#tab-chart_1

⁴⁵ Consumo di suolo e qualità dei suoli urbani, Rapporto APAT, Barberis *et al.*, 2006

Maps and figures

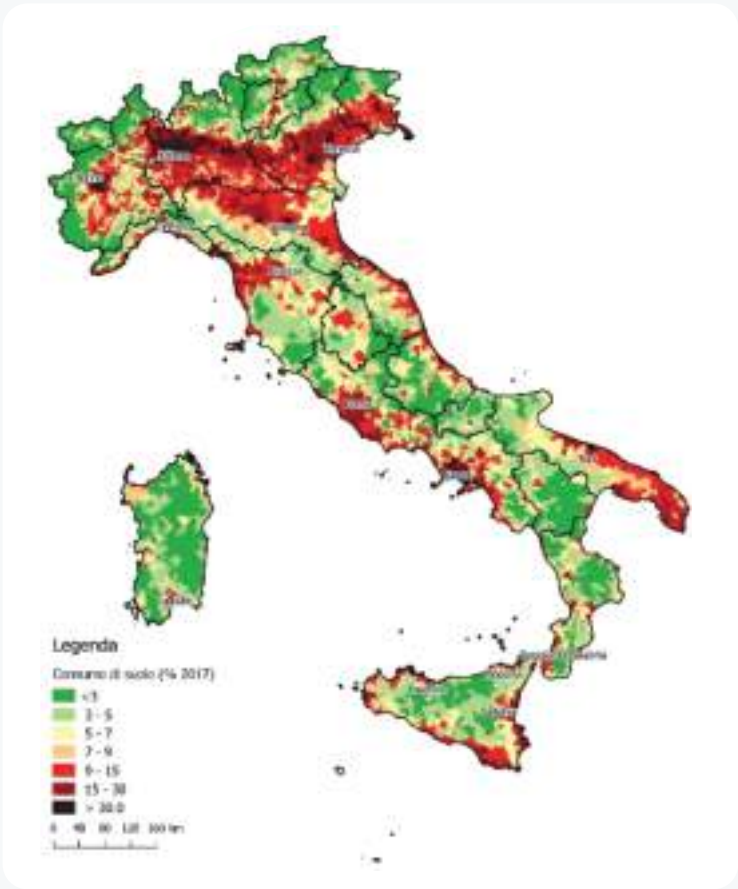


Figure 8 –
Land cover in Italy at municipal level in 2017

Source: ISPRA 2018

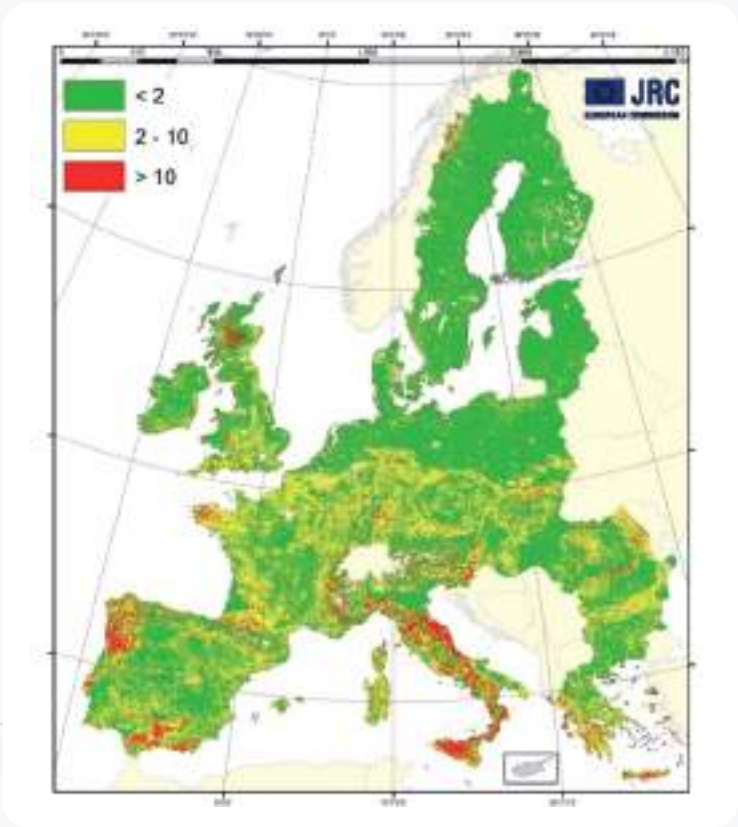
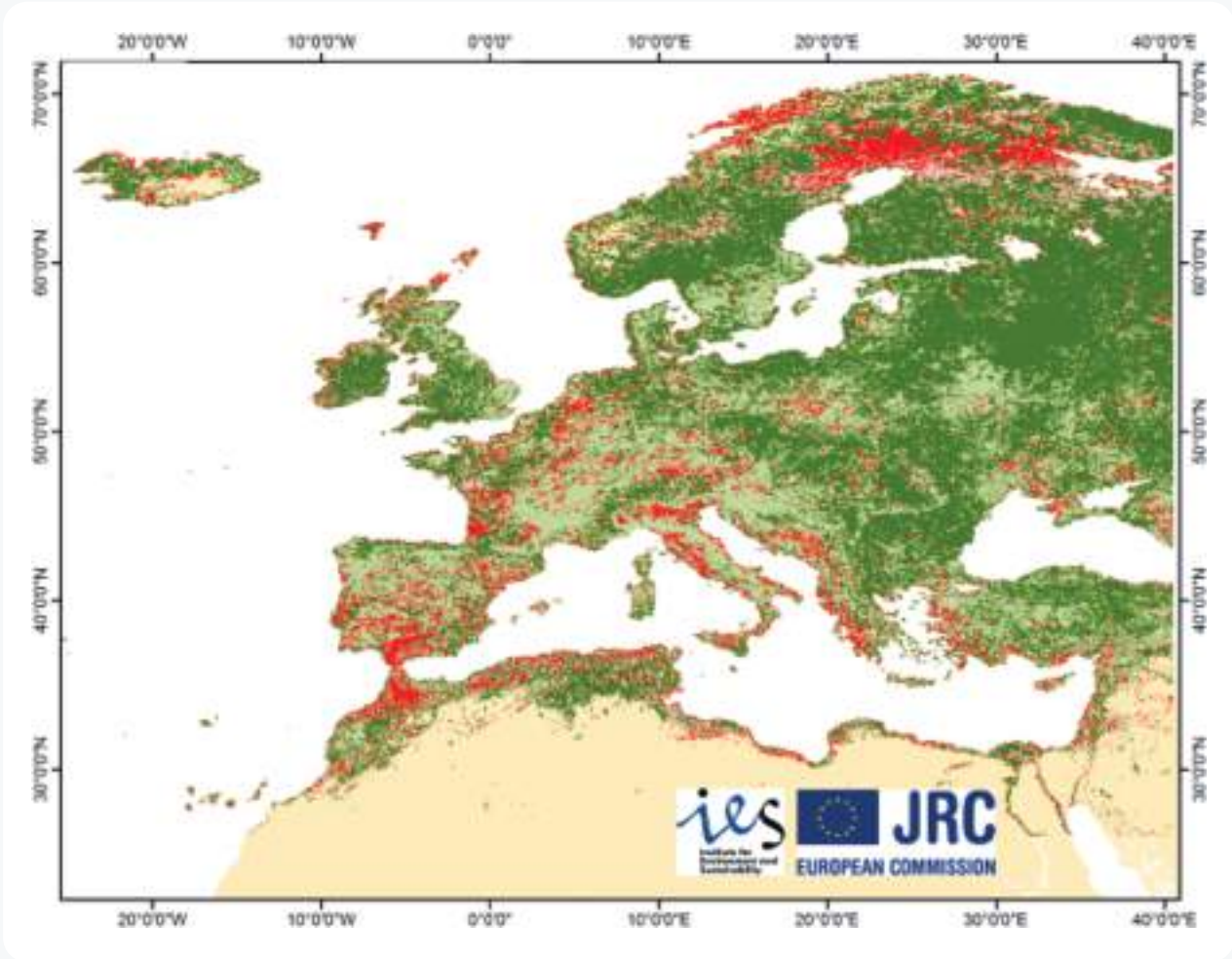


Figure 9 –
Soil erosion by water in the EU (t/ha/y)

Source: COM (2012) 46.

Figure 10 –
Evolution of net primary productivity (1982-2006)

Source: COM (2012) 46



- Unfavourable
- Favourable
- Fluctuating (negative)
- Fluctuating (positive)
- Bare areas

United Kingdom

The United Kingdom (UK) of Great Britain and Northern Ireland lies off the north west coast of continental Europe. It is made up of four nations:

- **England** (having 84% of the total population and 54% of the surface area);
- **Northern Ireland** (having 3% of the total population and 6% of the surface area);
- **Scotland** (having 8% of the total population and 32% of the surface area); and
- **Wales** (having 5% of the total population and 9% of the surface area).

Collectively, the UK had an estimated total population of 66.4 million people in 2018⁴⁶, with London being the most populous city.

The island of Great Britain (England, Scotland and Wales) lies to the north of France, and borders the North Sea on its eastern side, and the Atlantic Ocean and Irish Sea on its western side. It has a temperate climate and is generally drier on the eastern side than the west.

Each nation has its own specific policies and legislation governing environmental

protection. However, until the end of January 2020, it was the United Kingdom as a whole that was the member state of the European Union (EU), which compelled it to meet all EU directives and regulations. The UK's withdrawal from the EU places some uncertainty on future environmental policy and alignment with EU law.

This section focusses on England, as this is the nation of UK that has specific policies and information on soil health.

Legislation

There is no specific legislation addressing soil protection at either the UK or at a national level. Instead the main piece of legislation is the Environmental Protection Act (1990), which sets out measures to prevent pollution. In addition, there are numerous regulations and codes of practice covering the application of wastes and materials to land, and the prevention and remediation of contaminated land.



National strategies - England

The English Department for Environment, Food and Rural Affairs (DEFRA) published 'Safeguarding our Soils - A Strategy for England' in 2009⁴⁷. This set out the department's vision that: "By 2030, all England's soils will be managed sustainably and degradation threats tackled successfully. This will improve the quality of England's soils and safeguard their ability to provide essential services for future generations". It included measures on:

- Protecting and enhancing stores of soil carbon
- Building the resilience of soils to a changing climate

The soil strategy has been largely superseded by Defra's 25-Year Environment Plan, published in 2018⁴⁸. This sets out Government's vision for the environment and specifically aims to "improve soil health, and restore and protect peatlands".

National codes of practice

The main codes of practice aimed at the agricultural sector are the following:

- Protecting our Water, Soil and Air - A Code of Good Agricultural Practice for farmers, growers and land managers (England, 2009)
- Prevention of Environmental Pollution from Agricultural Activity (PEPFAA) Code (Scotland, 2005)
- The Code of Good Agricultural Practice (COGAP) - how you can help to avoid polluting water, air and soil (Northern Ireland, 2008)
- The Code of Good Agricultural Practice for the Protection of Water, Soil and Air for Wales (Wales, 2011)

These set out how farmers should manage their land in order to protect and enhance soil quality.

⁴⁶ <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/august2019>

⁴⁷ <https://www.gov.uk/government/publications/safeguarding-our-soils-a-strategy-for-england>

⁴⁸ <https://www.gov.uk/government/publications/25-year-environment-plan>

Land use in the UK – extent of the issue

Estimates for land use in the UK vary, depending upon the source of information.

In 2010 it was estimated that agriculture accounted for 153'330 km² (65%), forestry 30'590 km² and urban and developed land 27'480 km² (12%) out of a total 234'290 km². (Marine/coastal, freshwater and unclassified land made up the remainder at 22'890 km²)⁴⁹. A 2017 estimate suggested that 29% of the UK land cover was pastureland (used for grazing and fodder crops), with 27% classed as non-irrigated arable land (total of 56%)⁵⁰.

More recent data available for England, suggest that in 2017, 8% of the land was developed, with 92% not developed; agricultural land accounted for 63% of the total. The largest use of developed land was transport and utilities⁵¹. England is more urbanised than the other three nations of the UK.

A 2017 estimate suggested that **29%** of the UK land cover was pastureland



⁴⁹ Office for National Statistics – Land Use in the UK

⁵⁰ <https://www.sheffield.ac.uk/news/nr/land-cover-atlas-uk-1.744440>

⁵¹ <https://www.gov.uk/government/statistical-data-sets/live-tables-on-land-use>
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/808325/Land_Use_Experimental_statistic_England_2017.pdf

Specific threats to UK soils

Soils in the UK are relatively young, compared with soils in other parts of the world, having formed following the end of the Ice Age only about 10'000 years ago⁵². There is a large variation in the use and types of soils across the UK, due primarily to its geography: for example, the North West of Scotland is mountainous, sparsely populated and supports grazing animals; whilst the South East of England is heavily urbanised, of relatively low altitude and is farmed intensively.

Soil contamination: As some parts of the UK are heavily industrialised (e.g. refineries, factories and mines), it is estimated that in the region of 2-3'000 km² of soil are contaminated, depending upon the data source⁵³.

Soil organic matter: The UK's soils are thought to store somewhere in the region of 9.8 billion tonnes of carbon; however, this is decreasing at a rapid rate. A report by the UK Parliament's House of Commons Environmental Audit Committee, indicated that the "National Soil Inventory found a decrease of 5 grams per kilogram in arable soil carbon between 1978 and 2003"⁵⁴. It also suggested that the topsoil carbon concentration in arable soils fell by 11%.

The loss of soil organic matter is thought to be particularly acute in the East Anglian region of England. This is an agriculturally important area, growing significant quantities of arable crops, including cereals, potatoes and sugar beet. Organic matter losses are therefore thought to directly affect food security. One estimate suggests that the East Anglian Fens lose in the region of 380'000 tonnes of soil carbon a year; equivalent to 9% of the total soil carbon in England and Wales⁵⁵. A recent report by the Environment Agency suggested that the UK's arable soils have lost

between 40-60% of their organic matter due to intensive agriculture⁵⁶.

Soil erosion and compaction: Coupled with the losses of organic matter from the UK's soils, erosion and compaction are also thought to be problematic. In their report, the Environmental Audit Committee suggested that "that the UK's agricultural capacity is in danger, that the current rate of soil erosion is 10-100 times higher than it has been in the past, and that 2.2 million tonnes of soil is eroded each year in the UK"⁵⁷.

The Environment Agency suggested that in England and Wales about 40'000 km² of soil are at risk of compaction, and about 20'000 km² are at risk of erosion⁵⁸.

Costs: A study published in 2011 by Defra estimated that the annual costs of soil degradation in England and Wales were in the region of GBP 0.9 billion – 1.4 billion⁵⁹. The central estimate of GBP 1.2 billion a year is equivalent to EUR 1.4 billion a year.

Loss of organic matter was thought to account for 45% of the total cost, compaction 39% and erosion 13%. Overall, 20% of the total cost was due to loss of agricultural productivity/efficiency and 80% with loss of regulating services, such as greenhouse gas emissions.



Key data

Surface area of the UK	Agricultural surface area in use	Use of soil (urban & developed land)
234'290 km ²	153'330 km ²	27'480 km ²

⁵² House of Commons Environmental Audit Committee Soil Health First Report of Session 2016–17

⁵³ <https://www.forestresearch.gov.uk/tools-and-resources/urban-regeneration-and-greenspace-partnership/greenspace-in-practice/practical-considerations-and-challenges-to-greenspace/soil-contamination-issues-and-practical-considerations/>

⁵⁴ House of Commons Environmental Audit Committee Soil Health First Report of Session 2016–17

⁵⁵ Living Soils – A Call to Action (2016), Soil Association, UK.

⁵⁶ The State of The Environment: Soil (2019) Environment Agency, UK.

⁵⁷ House of Commons Environmental Audit Committee Soil Health First Report of Session 2016–17

⁵⁸ The State of The Environment: Soil (2019) Environment Agency, UK.

⁵⁹ Cost of Soil Degradation in England and Wales (2011), Defra, UK.

Maps and figures

Figure 11 – Land cover in the UK

Source: A Land Cover Atlas of the United Kingdom⁶⁰

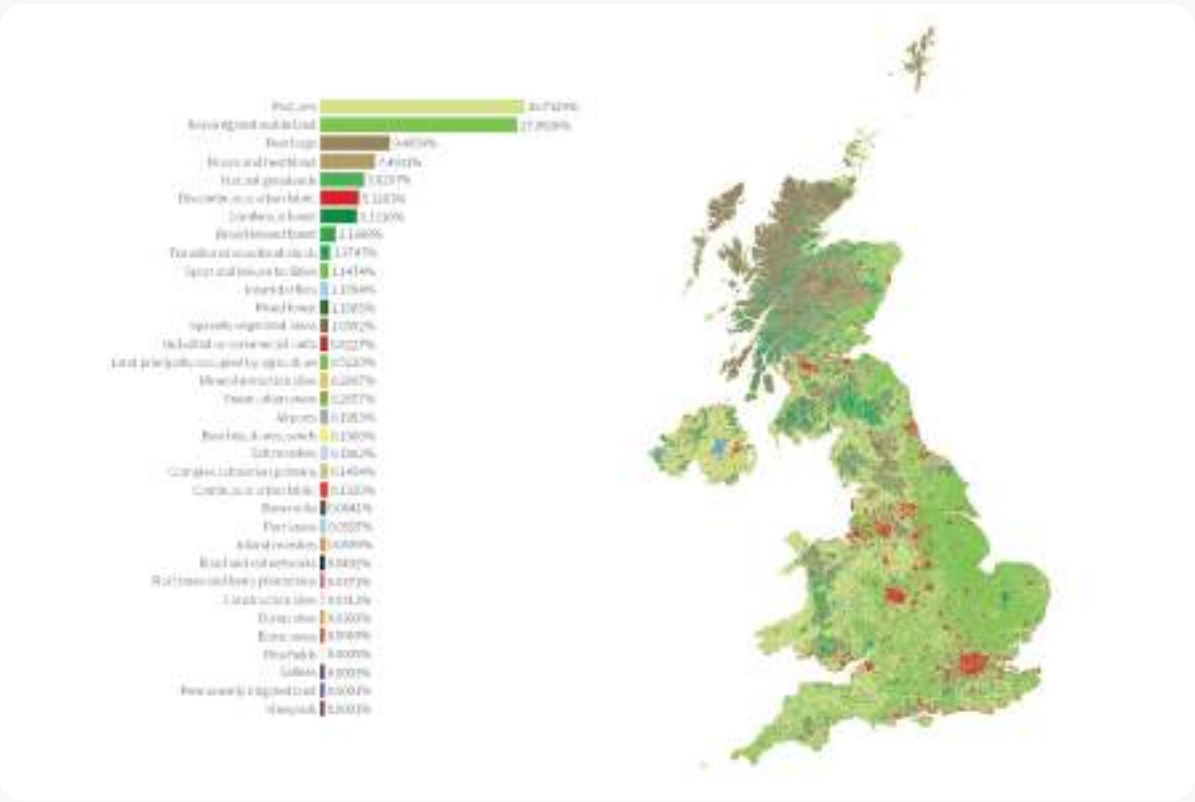


Figure 12 – Topsoil organic carbon content

Source: <https://esdac.jrc.ec.europa.eu/content/google-earth-files>

⁶⁰ Rae, Alasdair (2017): A Land Cover Atlas of the United Kingdom (Maps). figshare. Dataset. <https://doi.org/10.15131/shef.data.5219956.v1>
Produced by the University of Leicester, The Centre for Landscape and Climate Research and Specto Natura and supported by Defra and the European Environment Agency under Grant Agreement 3541/B2012/R0-GIO/EEA.55055 with funding by the European Union.

6 Conclusions

Of all the five countries studied, not a single one has in place national legislation protecting and enhancing soil; however, specific initiatives, policy documents and legislation can be found at the regional level (see examples of selected regions and Italy and England - UK). On the other hand, all five countries were also shown to suffer from soil erosion and loss of soil organic matter. The main threats to soil for each country are summarised in Table 2.

Table 2 – Summary of threats to soils in selected countries

COUNTRY	SOIL EROSION	LOSS OF SOIL ORGANIC MATTER	EXTENT OF DEGRADATION	MAIN CAUSES
Australia	About 53% of the land (i.e. 40 million ha) in regions with cropping and/or intensively managed grazing.	Soil carbon content is critical in about 33% of the soils (i.e. 25 million ha) in regions with cropping and/or intensively managed grazing.	An equivalent of 57% of the total land has been modified for agricultural or pastoral use in the last 200 years.	Extensive agricultural practises, settlement of the continent starting from 1788.
Brazil	800 million tonnes a year are lost.	SOM levels are naturally low, except in preserved areas. Tilling and grazing soils can result in a rapid decline in SOM levels, leading to degradation; this includes most grazing land.	Equivalent to 12% of agricultural land is degraded Equivalent to 7% of agricultural land is in process of severe desertification.	Deforestation, unsustainable land use practices & tropical climate.
Chile	Approximately 75% of productive agricultural land suffers from erosion, with 34% of this suffering severe erosion.	Desertification affects the equivalent of 62% of the national territory	In areas of severe erosion, 60% to 100% of soil depth suitable for cultivation has been lost.	Climate change and unsustainable land use practices.
Italy	29% of arable land lose soil at a rate of over 10 t/ha/yr. Over 70% of soil erosion occurs in 25% of croplands.	86% of soils have an organic carbon content falling in the pre-desertification range.	Over the last 25 years, desertification has caused a constant decline in the productivity of Italian soils.	Changes in forestry and permanent pastureland.
United Kingdom	The current rate of soil erosion is 10-100 times higher than it has been in the past. 2.2 million tonnes of soil are eroded each year.	The UK's arable soils have lost between 40-60% of their organic matter due to intensive agriculture	The costs of soil degradation in England and Wales have been estimated to be in the region of GBP 0.9 billion – 1.4 billion a year.	Intensive agricultural practices.

Note to Table 2 - Because of the way data about soil and land use are measured and collected, it has not been possible to make like-for-like comparisons between the different countries.

The implications of this are stark: for example, in Chile, there has been a decrease in agricultural productivity of just over 30%, with 93% of communes being adversely affected by desertification processes; whilst in the UK, the Committee on Climate Change suggested that “Some of the most productive agricultural land in England is at risk of becoming unprofitable within a generation due to soil erosion and the loss of organic carbon⁶¹”.

The combined effects of climate change and unsustainable land use practices is therefore, eroding soils at an unsustainable rate, threatening food security globally. The protection and enhancement of soils necessarily requires a multi-faceted approach involving, *inter alia*, changing land use and agricultural practices. This needs to be underpinned by legislation that is enforced effectively.

In all five countries, erosion and loss of organic matter could be reduced through the application of high-quality compost to soil.

A tentative correlation between the area of degraded land in each of the five countries, and the amounts of compost needed, at a minimum, to improve the organic matter content in soil has been estimated (Table 3). This was calculated based on the total amount of compost that may be produced if separate collection in each country would be able to divert towards composting 100% of all organic waste produced by municipalities, and assuming that only 1 tonne ha⁻¹ y⁻¹ would be applied to degraded soil, which is a very low application rate.

The results suggest that not a single country reviewed in this study would be able to either halt or reverse degradation if they were to rely solely on compost production by municipalities (Table 3). However, in the two

European countries assessed (IT and UK), the contribution made by adding compost to degraded soil could be significant. Other than Australia, the remaining countries could, in theory, improve significant areas of degraded soil by applying quality compost annually.

The challenge is to link the separate collection of organic wastes (especially in cities), its treatment and the production of quality soil improvers back onto agricultural land on which food is grown. More generally speaking, an holistic approach to achieve soil protection and enhancement should focus on closer teamwork between the initiatives of the circular economy applied to the recycling of organic waste and initiatives to restore the content of organic carbon in soils⁶². Without this circularity, it seems likely that our soil's ability to remain productive diminishes year-on-year; coupled with a growing global population, this urgently needs addressing.

Table 3 – Estimated area of degraded land that could benefit from composted organic waste application

COUNTRY	Agricultural surface area in use (km²)	Estimated area of degraded land ^a (km²)	Estimated percentage of degraded agricultural land	Estimated compost to degraded soil applied at 1 t/ha/year ^b (million tpa)	Equivalent amount of organic waste to recycle to manufacture compost ^c (million tpa)	Organic waste potential in each country ^d (million tpa)	Fraction of the potential supply of organic waste out of potential demand ^e
Australia	4'928'000	400'000	8%	40	121	3	3%
Brazil	2'519'203	478'649	19%	48	144	40	28%
Chile	460'000	117'300	26%	12	35	4	11%
Italy	127'000	36'830	29%	4	11	8	73%
United Kingdom	153'330	60'000	39%	6	18	9	50%

Note to Table 3 -

- a – Calculated based on information provided in this report
- b – Total quantity of compost calculated by assuming 1 tonne of compost is applied to 1 hectare of degraded land every year (1 km² = 100 hectares).
- c – This is the estimated quantity of organic waste that would need to be processed in order to apply 1 t ha⁻¹ year⁻¹ to degraded land. It conservatively assumes that only one third of the incoming waste will be transformed into compost to account for process and screening losses.
- d – Estimates by ISWA of the potential amount of organic waste available for composting.
- e – Fraction of the potential supply of organic waste out of the potential demand for organic waste to manufacture compost to apply to degraded land at 1 t ha⁻¹ year⁻¹. Mass estimates rounded to the nearest million tonnes.

⁶¹ Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament. Committee on Climate Change, UK

⁶² This is suggested also by the SOS Soil Initiative launched in October 2019 by the European Compost Network to urge EU decision makers to put forward consistent action to protect European soils, by linking the Circular Economy initiative on bio-waste with the Soil Strategy for Europe.



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He has 20 years of experience in planning MSW management, designing collection schemes by minimizing residual waste, assessing recycling facilities (focus on composting), planning communication initiatives, chairing multi-linguistic, multi-tasking working groups or projects. With a specific engagement for MSW solutions in cities, he supported the City of Milan (Italy) in

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Dr Jane Gilbert is a chartered environmentalist and waste management professional and has been involved in the organics recycling sector for over twenty years.

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Jane originally trained as a microbiologist (BSc Hons), has a doctorate (PhD) in biochemistry and a Masters in Business Administration

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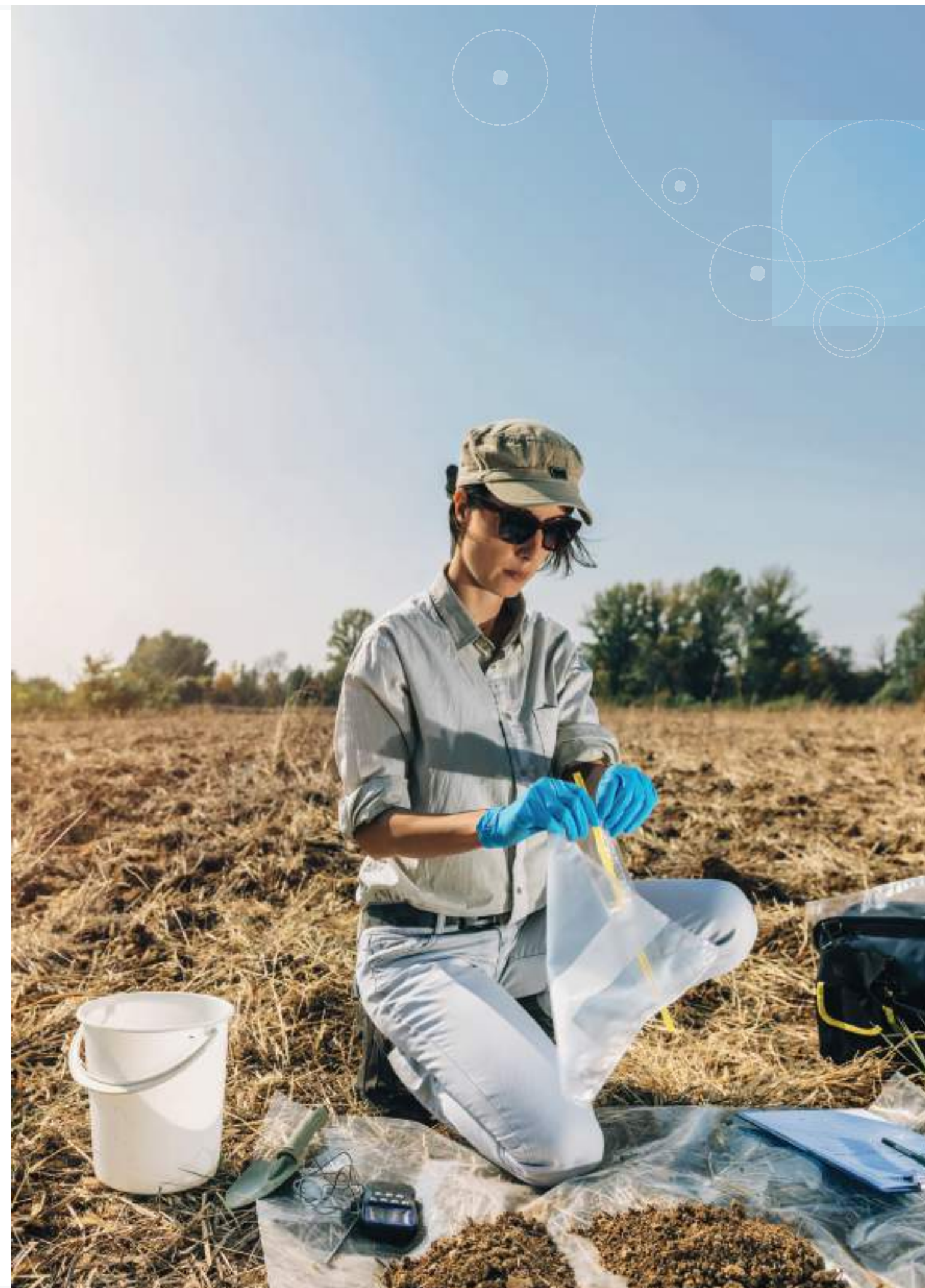
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Aditi is currently the Technical Director at the International Solid Waste Association (ISWA) where she manages international projects and partnerships with the UN, provides assistance to ISWA's Working Groups and helps develop innovative projects globally to further strengthen cooperation with ISWA's partners and international organizations.

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