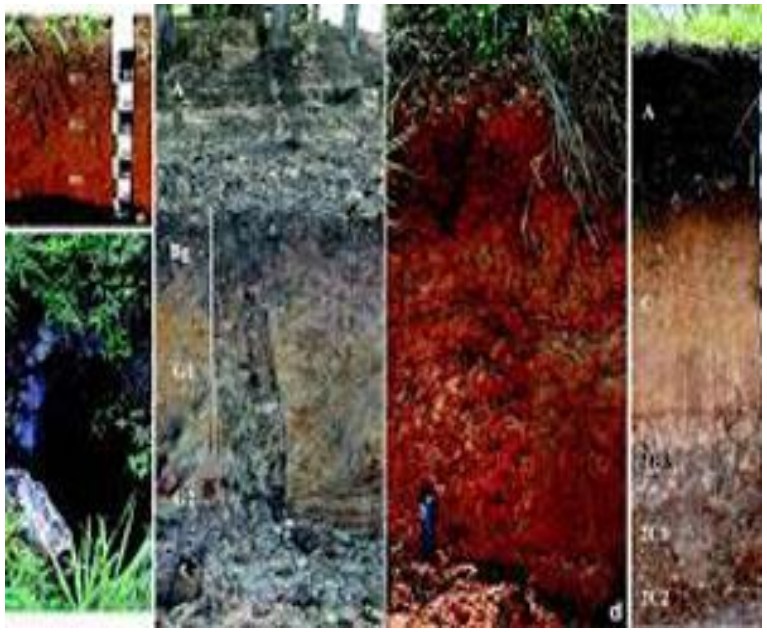
Manual on the Basic Set of Environment Statistics of the FDES 2013

Version 1.0

INSTITUTO NACIONAL DE ESTADÍSTICA Y GEOGRAFÍA



Topic 1.1.4

Soil Characteristics

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Component 1: Environmental Conditions and Quality				
Subcomponent 1.1: Physical Conditions				
Statistics and Related Information		Category of Measurement	Potential Aggregations and Scales	Methodological Guidance
(Bold Text - Core Set/Tier 1; Regular Text - Tier 2; Italicized Text - Tier 3)				
Topic 1.1.4 Soil characteristics				
			▪ By location ▪ By soil type ▪ National ▪ Sub-national	▪ FAO and the International Institute for Applied Systems Analysis (IIASA) Harmonized World Soil Database ▪ International Soil Reference and Information Centre (ISRIC) World Data Centre for Soils ▪ United Nations Convention to Combat Desertification (UNCCD) ▪ FAO Global Assessment of Human-induced Soil Degradation (GLASOD)
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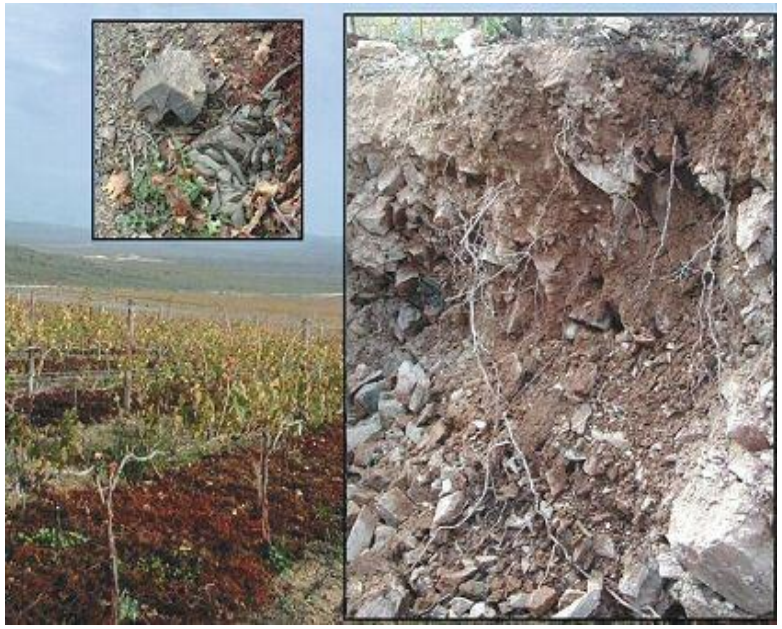

Introduction

Soil is a basic resource and a vital part of the natural environment in which most of the world's food is produced. In the same way, **the soil provides** vital space for human beings, as well as essential important **environmental services for the regulation and supply of water, climate regulation, conservation of biodiversity and cultural services**. However, soils are under pressure due to population growth, increased food demand and competition for land uses. **Approximately 33% of the world's soils are degraded** and political leaders around the world are exploring possibilities to adopt sustainable development through the objectives of sustainable development goals.[1]

In this context, the soil provides the physical platform for the production and cycle of biological resources, constitutes the basis for the construction of the infrastructure, is a source of nutrients and water for agricultural and forestry systems, provides a habitat for several organisms, plays an essential role in carbon sequestration, as well as plays an important role in environmental variability, ranging from buffering diurnal and seasonal changes in temperature and water supply to the storage of a wide range of chemical and biological agents.

Soils are fundamental for life on Earth, but human pressures on this resource are reaching critical limits. A greater loss of productive soils will increase the volatility of food prices and potentially cause millions of people to live in poverty. This loss is avoidable. Careful soil management can increase food supplies, and provide a valuable tool for climate regulation and a way to safeguard ecosystem services.[2]

1. FAO, Soil World Alliance webpage, http://www.fao.org/global-soil-partnership/about/why-the-partnership/en/ (accessed 11 January 2018)
2. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)

The main global drivers of soil change are population and economic growth.[3] While economic growth may eventually be decoupled from increases in resource consumption, the generation of waste will continue to be a strong driver of soil change at least during the following decades. **Relevant and important factors in soil change include education, cultural values, civil conflicts, market efficiency and wealth or poverty of land users.[4]**

These changes have been causing a number of threats to soil functions such as soil erosion, loss of soil organic carbon, nutrient imbalance, soil acidification, soil contamination, waterlogging, soil compaction, soil sealing, salination and loss of soil biodiversity. These threats to the health of the soil are reflected in its decreased capacity to produce goods and provide services to society.

For countries that depend heavily on agriculture and forestry, **knowledge of soils is also key to social and economic growth, and an understanding of the quality and resources of the soil are relevant in order to promote sustainable agriculture**.[5] Soil degradation, manifested mainly in the form of soil erosion, is considered one of the fundamental causes of stagnation or decline in agricultural productivity in South Africa and the Sahara, a situation that, together with the loss of soil organic matter, acidification, salination and waterlogging contribute to the food crisis in this region. In Europe, soil degradation due to inadequate management practices, urbanization and changes in land uses jeopardize the key role of soil ecosystems as a basis for the provision of ecosystem services.[6]

3. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)
4. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)
5. FAO Soils Portal webpage, http://www.fao.org/soils-portal/policies-governance/en/ (accessed 11 January 2018)
6. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)

Definitions and description of the statistics

Definition of Soil

Soil has also been defined as a natural body consisting of layers (soil horizons) that are composed of weathered mineral materials, organic material, air and water. Soil is the end product of the combined influence of climate, topography, organisms (flora, fauna and human) on parent materials (original rocks and minerals) over time. As a result, soil differs from its parent material in texture, structure, consistency, colour, chemical, biological and physical characteristics.

3A2. Soil characterization (FDES 1.1.4.a)

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Area by soil types (FDES 1.1.4.a.1)

Area of the dominant soil, understood as the soil that occupies more than 50% of the soil cover[7]

Remarks:

- This statistic may be obtained from soil maps.
- Soil classification systems can reflect dominant soils, codominant soils and associated soils, the latter two being soils which represents a lower percentage of the soil cover than dominant soils. For the purpose of the FDES only the dominant soils are included but not codominant or associated soils.

7. FAO (2015) *World Reference Base for Soil Resources 2014*, http://www.fao.org/3/a-i3794e.pdf (accessed 11 January 2018)

3A2. Soil degradation (FDES 1.1.4.b)

3A2. Soil degradation (FDES 1.1.4.b)

The change in soil health conditions, result of a diminished capacity of the ecosystem to provide goods and services for their beneficiaries. Degraded soils present a state of health that cannot provide the normal goods and services of the soil in their ecosystem[8]

Remarks:

- Of the complex factors leading to degradation, key processes of degradation are soil erosion and desertification.[9]
- Desertification is defined as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.[10]

8. FAO Soils Portal soil degradation webpage, http://www.fao.org/soils-portal/soil-degradation-restoration/en/ (accessed 11 January 2018)
9. FAO Soils Portal soil degradation webpage, http://www.fao.org/soils-portal/soil-degradation-restoration/en/ (accessed 11 January 2018)
10. United Nations (1994) *Elaboration of an International Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Paricularly in Africa*. A/AC.241/27, http://www.ifrc.org/docs/idrl/I223EN.pdf (accessed 11 January 2018)

Area affected by soil erosion (FDES 1.1.4.b.1)
Soil area with an absolute loss of soil and soil nutrients.[11]

Remarks:

- Soil erosion should not be confused with soil degradation
- Information on soil erosion can be obtained from remote sensing data

Area affected by desertification (FDES 1.1.4.b.2)
Area with irreversible change of land to a state such that it can no longer be recovered to its original use or land desertification in dryland areas, The UNCCD definition could also be used?[12] and is reflected in **the loss of its long-term capacity to supply goods and services to human populations.**

Remarks:

- Although this is a term used for arid zones, it is currently applied to all soils, as part of the degradation process
- Desertification statistics should be disaggregated into: light desertification, moderate desertification, severe desertification and extreme desertification

11. FAO Soils Portal soil degradation webpage, http://www.fao.org/soils-portal/soil-degradation-restoration/en/ (accessed 11 January 2018)
12. FAO Soils Portal, soil degradation webpage, http://www.fao.org/soils-portal/soil-degradation-restoration/en/ (accessed 11 January 2018)

Affected area by salinization (FDES 1.1.4.b.3)
Area with an increase of water-soluble salts in the soil including potassium, magnesium, calcium, chlorides, sulphates, carbonates and bicarbonates or high sodium content (sodification)[13]

Remarks:

- Soil salinization is a function of the amount of water-soluble salts in the soil, so it is related to the presence of calcium and potassium in soils

Area affected by waterlogging (FDES 1.1.4.b.4)
Area of soil with high humidity and where oxygen in the pore space is insufficient for the roots of plants to breathe properly. Other gases (detrimental to the growth of roots), such as carbon dioxide and ethylene, can also be present [14]

Remarks:

- Although this is a term used for arid zones, it is currently applied to all soils, as part of the degradation process

13. FAO (2016) Presentation, Salination and sodification of soil, http://www.fao.org/3/a-i6471e.pdf (accessed 11 January 2018)
14. FAO (2015) *Status of the World's Soil Resources. Technical Summary*, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)

Area affected by acidification (FDES 1.1.4.b.5)

Area with a decrease in soil pH due to the buildup of hydrogen and aluminium ions in the soil, and the associated loss of basic cations such as calcium, magnesium, potassium and sodium due to leaching or product removal.[15]

Area affected by compaction (FDES 1.1.4.b.6)

Area of soil surface whose porosity has been affected by the application of pressure to the surface thereof. The compaction prevents the functions of both, the superficial soil and subsoil, and inhibit the concentration of roots and the exchange of water and gases [16]

The nutrient information is derived from laboratory analysis of soil samples taken in the field which provide the specific distribution of these elements. Nutrient status in soil can be found in soil maps which include nutrient information or in the laboratory analysis reports of soil samples

15. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)
16. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)

3A3. Nutrient content in soil, measured in levels of (FDES 1.1.4.c)

3A3. Nutrient content in soil, measured in levels of (FDES 1.1.4.c)

The nutrients listed below are defined by their chemical composition, which is not redefined in this methodology sheet. However, under each a brief description is provided of their function for soil health.

Nitrogen (FDES 1.1.4.c.1)
Nitrogen is an important nutrient for plants and therefore for soil fertility. However, soil fertility is dependent not on availability of nutrients, but on nitrogen fixation[17]

Nitrogen absorbed by soil in the form of nitrates (NO3) and ammonium (NH4), in addition to the addition of nitrogenated fertilizers, influences the acidity of the soil by stabilizing its pH at 6-7, a value that allows the maximum availability of nutrients.

17. FAO (2016) Presentation Salination and sodification of soil, http://www.fao.org/3/a-i6471e.pdf (accessed 11 January 2018)

Phosphorous (FDES 1.1.4.c.2)

Phosphorous is vital for the growth and health of plants, **assists in the conversion of energy from the sun and other chemicals such as nitrogen, into appropriate foods for plants**. A deficiency of phosphorous will make plants look stunted and sick and produce low quality flowers and fruits, but with the correct amount of this element, will grow vigorously and mature earlier than plants that do not.

Phosphorous functions as one of the main players in photosynthesis, nutrient transport and energy transmission. Phosphorous also affects the structure of the plant at the cellular level.[18]

Calcium (FDES 1.1.4.c.3)

Calcium is an element that contributes to soil fertility, is an essential element for soil microorganisms that transform crop residues into organic matter in the soil; its presence contributes to reduced soil salinity and improves water penetration, and in association with humic acid forms a characteristic structure that allows aeration of the soil. The excessive presence of calcium, together with other elements, is an important factor in the salinization of soils.

18. Servicios Agropecuarios de la Costa S.A. de C.V. (SACSA), *Importancia del fósforo por las plantas* (Importance of phosphorous for plants) webpage, http://www.gruposacsa.com.mx/importancia-del-fosforo-por-las-plantas/ (accessed 11 January 2018)

Magnesium (FDES 1.1.4.c.4)

Magnesium is an essential nutrient; **its presence in excess in the soil can cause degradation in its physical conditions and together with other elements cause its salinization**, while its presence can be affected by erosive processes.[19]

Potassium (FDES 1.1.4.c.5)

Potassium is one of the main macronutrients, [20] **in excess, its presence contributes to the salinization of the soil, which is also caused by inadequate irrigation practices**.[21]

19. Mikelsen, R., Fuentes de Magnesio webpage (Magnesium Sources), https://ipni.net/ppiweb/iaecu.nsf/$webindex/0FF40EBB414EF2B10525777D0075087B/$file/3.+Fuentes+de+Magnesio.pdf (accessed 11 January 2018)

20. Universidad Nacional Autónoma de Madrid, Museo Virtual sobre nutrición mineral en cultivos de plantas: fundamentos de nutrición mineral: macronutrientes: Potasio, (Potassium), https://www.uam.es/docencia/museovir/ (accessed 11 January 2018) [link not working]

21. Universidad Nacional Autónoma de Madrid, Museo Virtual sobre nutrición mineral en cultivos de plantas: fundamentos de nutrición mineral: macronutrientes: Potasio, (Potassium), https://www.uam.es/docencia/museovir/ (accessed 11 January 2018) [link not working]

Other/Carbon (FDES 1.1.4.c.7)

The category other of the FDES should be broken down to include Carbon. FDES (Soil Organic) **Carbon is an important element in soils, incorporated by the decomposition of the organic matter, (48 to 58% of soil weight). Soils are key to regulation of the emission of carbon dioxide and other greenhouse gases as they contain more carbon than all the vegetation on earth.**[22]

Loss of soil organic carbon due to soil degradation is considered an important contributor to greenhouse gas accumulation and climate change; it is currently estimated that there has been a 59% loss in the availability of carbon in soil in the conversion of grasslands to crops.[23]

Other/Soil pH (FDES 1.1.4.c.7)

Soil **pH is an important element of soil productivity which measures soil acidity or alkalinity**. A pH of 7 is neutral, greater than 7 basic or alkaline and below 7 acidic. The nutrition, growth and yields of crops decrease with a low pH and increase at optimum pH which varies by crop.[24]

22. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)
23. FAO (2015) Status of the World's Soil Resources. Technical Summary, http://www.fao.org/3/a-i5126e.pdf (accessed 11 January 2018)
24. FAO Soils Portal: Acid soils website, http://www.fao.org/soils-portal/soil-management/management-of-some-problem-soils/acid-soils/en/ (accessed 7 January 2018)

International sources and recommendations

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4A. Classifications and groupings

4A1. The World Reference Base for Soil Resources (WRB)[25]

The World Reference Base for Soil Resources (WRB) is an international standard for classification systems of soil groups approved by the International Union of Soil Sciences.[26] It provides soil groups and rules for creating map legends, in terms of how to characterize map units which do not have a homogenous soil type. **Map units can consist of dominant, codominant or associated soils or combinations of these.**

It has been used to generate legends for soil inventory maps. **Statistics are derived from the soil maps generated by countries and international organizations.** It is not intended to replace any national soil classification system, but rather to be a common denominator for international communication

The WRB groups the soils as follows:

Histosols	Solonchaks	Plantosols	Gypsisols	Cambisols
Anthrosols	Gleysols	Stangosols	Calcisols	Arenosols
Technosols	Andosols	Chernozems	Retisols	Fluvisols
Cryosols	Podsols	Kastanozems	Acrisols	Regosols
Leptosols	Plintosols	Phaeozems	Lixisols	
Solonetz	Nitisols	Umbrisols	Alisols	
Vertisols	Ferralsols	Durisols	Luvisols	

25. FAO (2015) World Reference Base for Soil Resources 2014: international soil classification system for naming soils and creating legends for soil maps, World soil resources reports 106, http://www.fao.org/3/a-i3794e.pdf (accessed 11 January 2018)
26. FAO Soils Portal World Reference Base for Soil Resources webpage, http://www.fao.org/soils-portal/soil-survey/soil-classification/world-reference-base/en/ (accessed 11 January 2018)

4A2. USDA Soil Taxonomy, Soil Conservation Service of the United States Department of Agriculture

The USDA Soil Taxonomy, published in 1975 by the Soil Conservation Service of the United States Department of Agriculture, is a basic system of soil classification to elaborate and interpret soil surveys. A second edition has been published in 1999.[27] and further revisions incorporated into the Keys to Soil Taxonomy[28] which provides the taxonomic keys necessary for the classification of soils in a form that can be used easily in the field. **The system follows a hierarchical model that groups similar soils into very general categories.**

Although it is a national standard its basic principles were used in forming the World Resource Base and the FAO Soil Legend[29] As it is a seminal work in the establishment of international standards, it is mentioned in the methodology sheet. The system is also internationally recognized, being used mainly in Latin America and Asia.

27. United States Department of Agriculture, Natural Resources Conservation Service (1999) Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys, 2nd ed., https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf (accessed 11 January 2018)
28. United States Department of Agriculture, Natural Resources Conservation Service (2014) Keys to Soil Taxonomy, 12th edition, https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580 (accessed 11 January 2018)
29. FAO (2015) World Reference Base for Soil Resources 2014: international soil classification system for naming soils and creating legends for soil maps, World soil resources reports 106, http://www.fao.org/3/a-i3794e.pdf (accessed 11 January 2018)

It classifies the soils into 12 large groups:

Alfisols	**Inceptisols**
Andisols	Mollisols
Aridisols	Oxisols
Entisols	Spodosols
Gelisols	Ultisols
Histosols	Vertisols

30. FAO (2011) Land Degradation and Assessment in Drylands: Manual for Local Level Assessment of Land Degradation and Sustainable Land Management, LADA Project, http://www.fao.org/nr/kagera/tools-and-methods/lada-local-level-assessment-manuals/en/ (accessed 11 January 2018)

4A3. Soil Erosion

There is no official international classification of soil erosion. However, the **FAO Local Level Assessment of Land Degradation and Sustainable Management[30] provides types and forms of erosion by wind and water, including degree of erosion**.

This covers by water the major types below, with more detailed types:

- Erosion by raindrop impact (splash)
- Sheet erosion
- Linear erosion
- Mass movement

and by wind, the major types with more detailed types:

- Deflation
- Accumulation

30. FAO (2011) Land Degradation and Assessment in Drylands: Manual for Local Level Assessment of Land Degradation and Sustainable Land Management, LADA Project, http://www.fao.org/nr/kagera/tools-and-methods/lada-local-level-assessment-manuals/en/ (accessed 11 January 2018)

4B. Reference to international statistical recommendations, frameworks and standards

- FAO (2015) Status of the World's Soil Resources, provides regional assessments of soil change.[31]
- FAO (2015) Status of the World's Soil Resources, provides regional assessments of soil change[32]. developed to provide a voluntary standard for sustainable soil management and to provide guidance on realizing this in practice.
- FAO (1996) Land Quality Indicators and Their Use in Sustainable Agriculture and Rural Development provides information on developing indicators of soil quality and their measurement[33].
- FAO (2017) Soil Organic Carbon Mapping Cookbook[34] provides information on mapping of soil organic carbon FAO (2017) *Soil Organic Carbon Mapping Cookbook*, http://www.fao.org/3/a-bs901e.pdf (accessed 11 January 2018)
- Guidance on how to present soil statistics can be found in the metadata for the international and regional databases discussed in section 4C. i.e., World Inventory of Soil Emission Potentials (WISE), World Soils and Terrain Digital Database (SOTER), and regional databases for Asia, Global Assessment of the Status of Human-induced Soil Degradation (GLASOD) and Regional Assessment of the Status of Human-induced Soil Degradation in South and Southeast Asia (ASSOD).
- United Nations Convention to Combat Desertification provides guidance on sustainable land management and land degradation neutrality[35].

31. FAO (2015) Status of the World's Soil Resources, http://www.fao.org/documents/card/en/c/c6814873-efc3-41db-b7d3-2081a10ede50/ (accessed 11 January 018)
32. FAO (2017) Voluntary Guidelines for Sustainable Soil Management, http://www.fao.org/3/a-bl813e.pdf (accessed 11 January 2018)
33. FAO (1996) Land Quality Indicators and Their Use in Sustainable Agriculture and Rural Development, http://www.fao.org/docrep/W4745E/w4745e00.htm#Contents (accessed 11 January 2018)
34. FAO (2017) Soil Organic Carbon Mapping Cookbook, http://www.fao.org/3/a-bs901e.pdf (accessed 11 January 2018)
35. UNCCD publications webpage, https://www2.unccd.int/publications (accessed 11 January 2018)

4C. Sources of global and regional environment statistics and indicators series

FAO/UNESCO Soil Map of the World

Presents soil statistics of different countries of the world starting from 1960 to 1980, presented globally and regionally at 1: 5 000 000 scale. Data for the map are provided by national institutions. As countries use national soil classification systems, data can be provided under other classifications such as soil taxonomy. Found at http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/.[36]

Harmonized World Soil Database v 1.2[37]

The FAO Harmonized World Soil Database, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/; in partnership with IIASA, ISRIC-World Soil Information, Institute of Soil Science, Chinese Academy of Sciences and the Joint Research Centre of the European Commission is a 30 arc-second raster database covering terrain, land cover, soil quality, including nutrients, salinization. It updates the FAO/UNESCO Soil Map of the World with national and regional information including databases of SOTER, European Soil Data Centre (ESDAC), Soil Map of China, WISE.

Legacy maps from scanned paper maps based on field survey data can be found at: http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/en/

36. FAO (1971) *FAO/UNESCO Soil Map of the World* webpage, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/ (accessed 11 January 2018)
37. FAO Harmonized World Soil Database v 1.2 webpage, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/ (accessed 11 January 2018)

International Soil Reference and Information Centre (ISRIC) Soil Data Hub

ISRIC is an independent foundation providing scientific information on soils. It is globally recognized and partners with FAO on several publications, including the World Reference Base for Soil Resources, http://www.isric.org/projects/world-inventory-soil-emission-potentials-wise.[38] Previously its database was known as ISIS: ISRIC Soil Information System. Its current data products include SoilGrids 250m and 1km outputs of ISRIC's automated global soil mapping system, and World Soil Information Service (WoSIS) Soil Profile Database. SoilGrids provides modelled data on soil mapping; and WoSIS provides georeferenced point data of soil profiles, without adjustment.

World Inventory of Soil Emission Potentials (WISE)[39]

WISE was implemented by ISRIC between 1991-2016, http://www.isric.org/projects/world-inventory-soil-emission-potentials-wise. It is a global soil database, linked by means of GIS to the FAO-UNESCO Soil Map of the World.[40] It shows the carbon emissions potentials of soils and has been linked to the SOTER databases creating the SOTWIS products.

38. FAO (2015) World Reference Base for Soil Resources 2014: international soil classification system for naming soils and creating legends for soil maps, World soil resources reports 106, http://www.fao.org/3/a-i3794e.pdf (accessed 11 January 2018)
ISRIC, World Inventory of Soil Emission Potentials (WISE) webpage, http://www.isric.org/projects/world-inventory-soil-emission-potentials-wise (accessed 11 January 2018)
39. FAO (1971) FAO/UNESCO Soil Map of the World webpage, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/ (accessed 11 January 2018)
40. FAO Harmonized World Soil Database v 1.2 webpage, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/ (accessed 11 January 2018)

(World) Soils and Land of the World (SOTER)[41]

SOTER, http://www.isric.org/projects/soil-and-terrain-soter-database-programme, developed by FAO, ISRIC and UN Environment in 1986, provides terrain and soil data in GIS polygons at varying scales at continental, regional, national and district – generally above 1: 1 million. Also hosted are the SOTER-based soil parameter estimates (SOTWIS) products, which incorporate more standardized soil profile data

Global Soil Organic Carbon Map V1.[42]

The Soil Organic Carbon map, http://www.fao.org/global-soil-partnership/pillars-action/4-information-and-data/global-soil-organic-carbon-gsoc-map/en/, shows the current soil organic carbon stock.

41 FAO, UN Environment and ISRIC, *Soils and Land of the World database* webpage, http://www.isric.org/projects/soil-and-terrain-soter-database-programme (accessed 11 January 2018)39. FAO (1971) FAO/UNESCO Soil Map of the World webpage, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/ (accessed 11 January 2018)

42. FAO *Global Soil Organic Carbon Map V1.0*, http://www.fao.org/global-soil-partnership/pillars-action/4-information-and-data/global-soil-organic-carbon-gsoc-map/en/ (accessed 11 January 2018)

United Nations Convention to Combat Desertification reporting process http://www2.unccd.int/convention/2017-2018-unccd-reporting-process, provides data on countries progress in meeting the 2018-2030 Strategic Framework which aims to avoid, minimize and reverse desertification/land degradation and mitigate the effects of drought and to achieve land degradation neutrality.[43] . It should be noted that the reporting indicators go beyond soils to reflect a broader range of conditions including ecosystem condition, conditions of affected populations, mitigation and adaptation activities to manage the effects of drought and resource mobilization. Objectives specific to this FDES topic are:

Strategic objective 1: To improve the condition of affected ecosystems: SO 1-3 Trends in carbon stocks above and below ground.

Strategic objective 4: To generate global environmental benefits through effective implementation of the United Nations Convention to Combat Desertification: SO 4-1 Trends in carbon stocks above and below ground.

43. FAO, UN Environment and ISRIC, *Soils and Land of the World database* webpage, http://www.isric.org/projects/soil-and-terrain-soter-database-programme (accessed 11 January 2018)

Assessment of Soil Degradation in South and Southeast Asia (ASSOD)

ASSOD[44] and Global Assessment of Soil Degradation (GLASOD), http://www.isric.org/projects/assessment-soil-degradation-south-and-southeast-asia-assod, developed from 1995 to 1997 by ISRIC is an assessment of soil degradation for South and Southeast Asia using the Global Assessment of Human-induced Soil Degradation (GLASOD)[45] methodology. It uses the physiography of the SOTER. Under the GLASOD project a world map of human-induced soil degradation was prepared from 1988 to 1991. The soil degradation related to water erosion, wind erosion, chemical deterioration and physical deterioration, with varying levels of soil degradation.

European Union, Land Use and Cover Area frame Survey (LUCAS)

LUCAS, http://ec.europa.eu/eurostat/web/lucas/methodology, includes a soil module collecting data from the topsoil (the superficial 20 cm) for 10% of LUCAS sample points. It provides data on soil properties of coarse fragments, pH, organic carbon, carbonates, phosphorous, total nitrogen, extractable carbonate, cationic exchange capacity and heavy metals is available. Data are available for 2009, 2012, 2015.[46]

Statistical Office of the European Union (Eurostat), Soil Statistics

Data are provided on soil types and human-induced water and wind erosion of soil by country, based on models supported by geological, climatic and land use information. [47]

44. ISRIC *ASSOD website*, http://www.isric.org/projects/assessment-soil-degradation-south-and-southeast-asia-assod (accessed 11 January 2018)
45. ISRIC, *GLASOD methodology*, http://www.isric.org/projects/global-assessment-human-induced-soil-degradation-glasod (accessed 11 January 2018)
46. European Commission, LUCAS survey website, http://ec.europa.eu/eurostat/web/lucas/methodology (accessed 11 January 2018)
47. Eurostat, *Environmental Data Centre on Natural Resources, Soil* webpage, http://ec.europa.eu/eurostat/web/environmental-data-centre-on-natural-resources/natural-resources/soil (accessed 11 January 2018)

Transforming data into environment statistics

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5A. Data collection and sources of data

The statistical information of soils originates from the data sources produced by the national offices responsible for generating them, as well as that produced by academic institutions and researchers; this last knowledge enriches the information produced by soil inventories.

Scope of the statistics
All soils in countries

Statistical unit
Soils are generally grouped into *soil mapping units* which are areas which are coherent in terms of their soil components. They can contain one soil type or multiple soil types. These are the basic unit of a soil map.

Measurement unit
The measurement unit varies according to the nature of the data collection. Traditionally soil data has been collected using soil surveys where the measurement unit would be a sample point. Soil data obtained from remote sensing data would not have measurement units, but the units correspond to the pixels and resolution of the images.

Sources and institutions

Data on soils are obtained from several sources:

- **Remote sensing (land cover and land use)**
- **Soil surveys, with resulting thematic maps**
- **Administrative records**
- **Scientific studies**

Some countries lack soil inventories, in which case the global datasets produced by FAO may be useful.

There is currently no harmonized system of soil information. FAO is working with member states to implement **the World Reference Base for Soil Resources[48] with the support of the USDA Soil Taxonomy[49] to provide harmonized world-wide data on soils**. This would harmonize approaches to determine the main functional properties of soils, i.e., chemical, physical and biological characteristics of the soil; and to review existing indicators and evaluation procedures to develop harmonized criteria, baselines and thresholds. This will also support review of criteria for evaluation of soil degradation.

48. FAO (2015) World Reference Base for Soil Resources 2014: international soil classification system for naming soils and creating legends for soil maps, World soil resources reports 106, http://www.fao.org/3/a-i3794e.pdf (accessed 11 January 2018)
49. United States Department of Agriculture, Natural Resources Conservation Service (1999) Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys, 2nd ed., https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf (accessed 11 January 2018)

Data collections

Various information on data collection using traditional surveys and digital techniques, from international and national sources, can be found on the FAO Soils Portal.[50]

Techniques for measuring land degradation can be found under the Land Degradation and Assessment in Drylands (LADA) project of FAO.[51]

Aggregation

Temporal and spatial aspects

International soil data are compiled from a variety of national sources and the reference periods may vary. Soil characteristics change slowly, therefore datasets produced several years ago are still in use.

50. *FAO Soils Portal, Soil survey, digital soil mapping and traditional soil survey methodologies*, webpage http://www.fao.org/soils-portal/soil-survey/en/ (accessed 11 January 2018)

51. FAO (2011) *Land Degradation and Assessment in Drylands: Manual for Local Level Assessment of Land Degradation and Sustainable Land Management*, LADA Project, http://www.fao.org/nr/kagera/tools-and-methods/lada-local-level-assessment-manuals/en/ (accessed 11 January 2018)

Uses and dissemination

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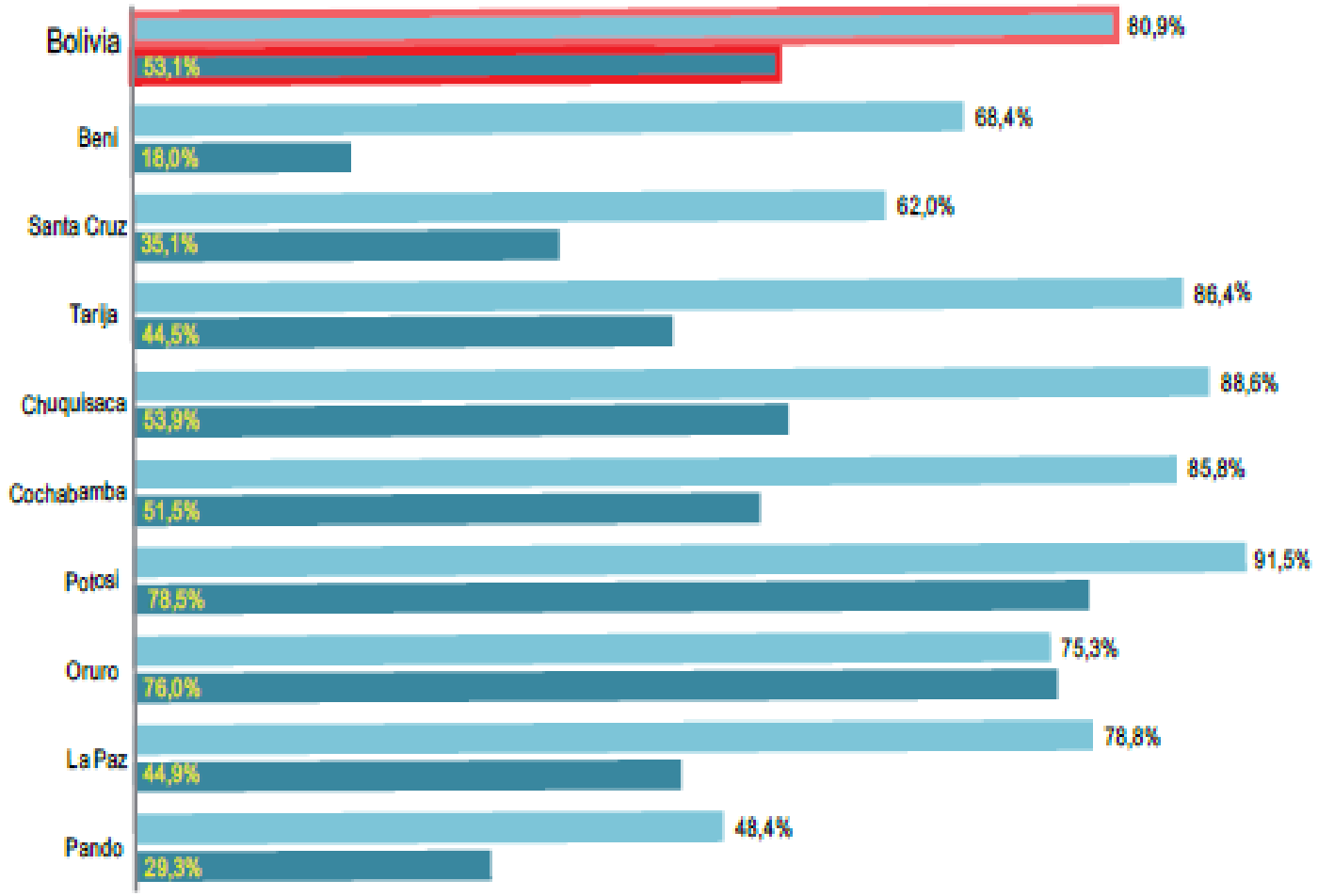
6A. Potential presentation/dissemination formats

Figure 6.1 Water and wind erosion in the Republic of Argentina

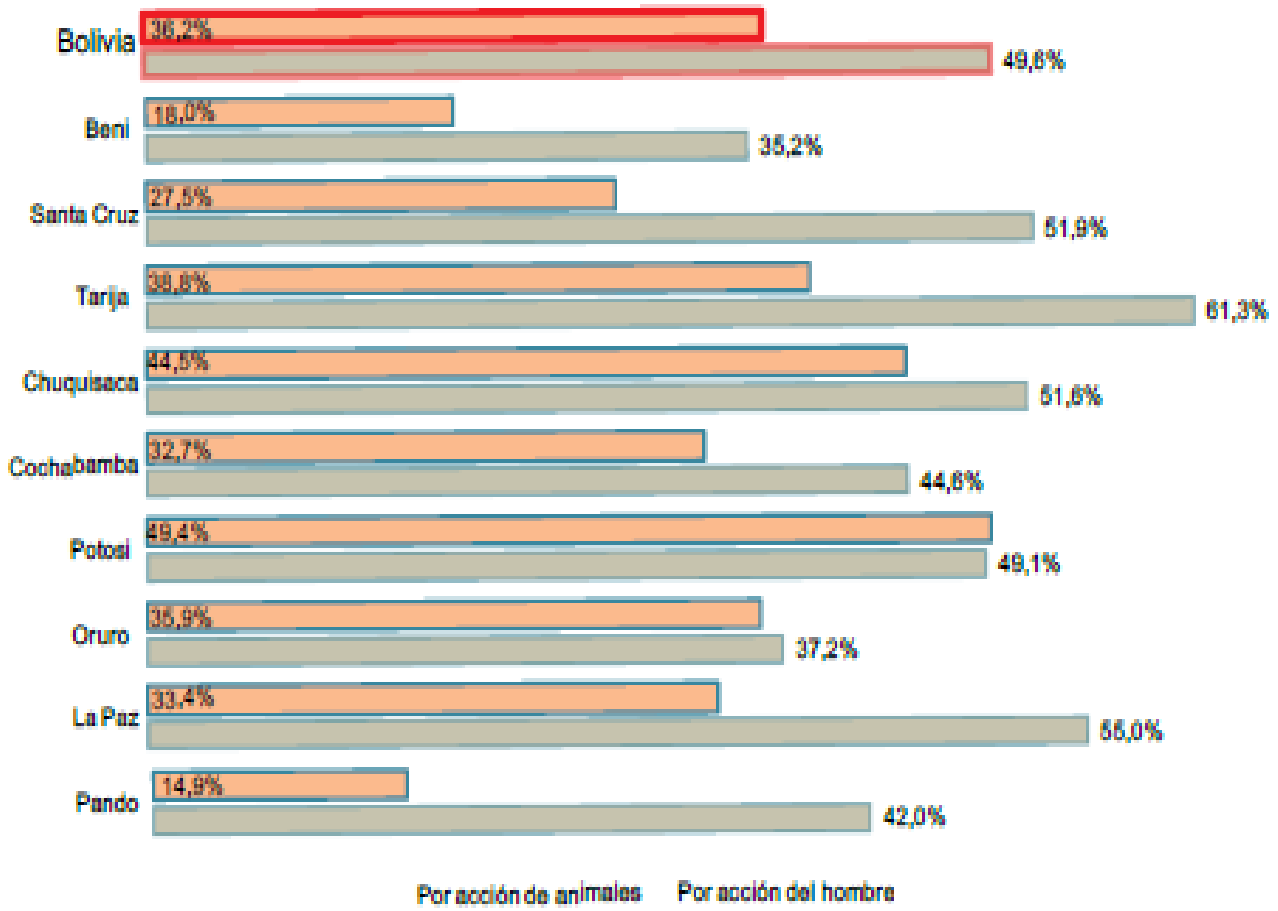
	Moderate		Serious/Severe		Total	
	ha	%	ha	%	ha	%
Hidric (water) erosion	15 382 000	62	9 626 000	38	25 008 000	100
Eolic (wind) erosion	7 020 000	33	14 390 000	67	21 410 000	100
Total	22 402 000	48	24 016 000	52	46 418 000	100

Source: FAO (1992) Erosion de suelos en America Latina: La erosion del suelo en la República Argentina, http://www.fao.org/docrep/t2351s/T2351S00.htm#Contents (accessed 11 January 2018) Shows area affected by water and wind erosion at national level.

Figure 6.2 Bolivia, causes of soil erosion by department 2013



Fuente: Instituto Nacional de Estadística



Source: Estado Plurinancional de Bolivia (2014) Un Pincelazo a las estadísticas con base a datos de censos: Censo Nacional Agropecuario 2013. http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_5/BOL_SPA_REP_2013.pdf (accessed 11 January 2018)

Shows levels of water and wind erosion, for each department, and the percentage of total erosion caused by animals and by human-intervention.

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Figure 6.3 European Union, Estimated soil erosion by water - area eroded by more than 10 tons per hectare per year, 2000, 2010 and 2012

unit: Percentage

geo \ time	2000	2010	2012
EU (28 countries)	5.99	5.26	5.16
Belgium	0.70	0.41	0.41
Bulgaria	4.82	3.01	2.86
Czech Republic	2.77	1.34	1.26
Denmark	0.01	0.01	0.00
Germany	2.46	1.37	1.22
Estonia	0.01	0.00	0.00
Ireland	0.72	0.68	1.13
Greece	10.79	9.41	9.72
Spain	10.92	8.85	8.42
France	4.14	3.39	3.37
Croatia	7.78	6.95	6.89
Italy	25.83	24.61	24.58
Cyprus	8.54	6.12	6.18
Latvia	0.01	0.01	0.01
Lithuania	0.03	0.02	0.02
Luxembourg	3.60	2.68	2.67
Hungary	2.94	2.57	2.37
Malta	28.64	11.36	12.74
Netherlands	0.02	0.01	0.01
Austria	15.43	15.55	15.94

Source: Eurostat, soil erosion statistics webpage, http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_rn300&plugin=1 (accessed 11 January 2018.

Figure 6.4 Gross nutrient balance in agricultural land (Phosphorous, kilograms per hectare per year), 2001-2009

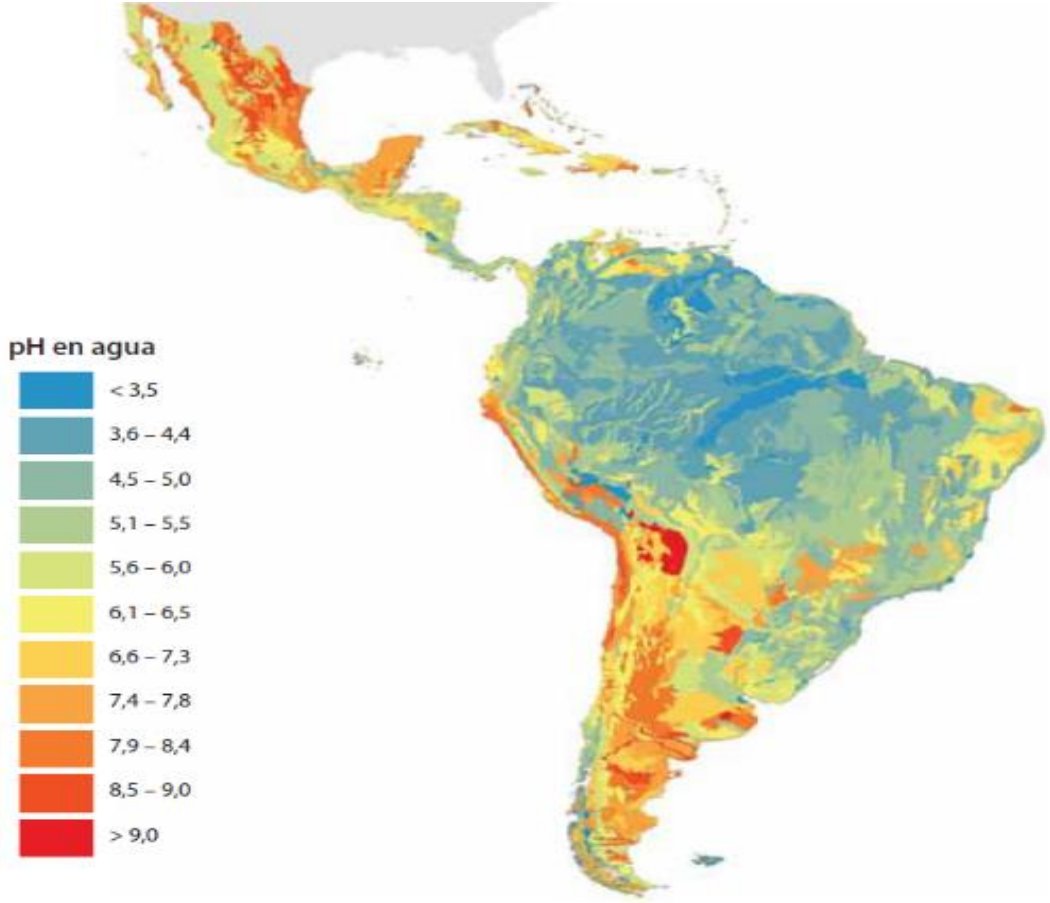
Gross nutrient balance on agricultural land
kilograms per hectare
The gross nutrient balance represents the total potential threat to the environment of ... more

nutrient: Phosphorus

geo \ time	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU (28 countries)	:	:	:	4[e]	4[e]	4[e]	4[e]	2[e]	1[e]
Belgium	16[e]	15[e]	12[e]	11[e]	11[e]	10[e]	9[e]	4[e]	2[e]
Bulgaria	-3[e]	-3[e]	0[e]	-3[e]	-2[e]	-2[e]	0[e]	-4[e]	-4[e]
Czech Republic	1	2	4	0	0	1	2	0	-5
Denmark	14[e]	14[e]	13[e]	13[e]	11[e]	12[e]	12[e]	7[e]	7[e]
Germany	3	3	7	0	2	2	2	2	-2
Estonia	:	:	:	-5	-7	-2	-7	-5	-6
Ireland	7	7	8	8	7	6	5	1	:
Greece	5[e]	6[e]	7[e]	4[e]	3[e]	4[e]	4[e]	2[e]	3[e]
Spain	8[e]	8[e]	7[e]	7[e]	7[e]	5[e]	6[e]	1[e]	3[e]
France	8	6	8	5	5	4	4	4	-2
Croatia	14[e]	11[e]	15[e]	11[e]	12[e]	18[e]	12[e]	9[e]	1[e]
Italy	5[e]	5[e]	6[e]	0[e]	0[e]	3[e]	2[e]	-3[e]	0[e]
Cyprus	33[e]	35[e]	30[e]	29[e]	28[e]	28[e]	31[e]	33[e]	29[e]
Latvia	1[e]	1[e]	1[e]	1[e]	2[e]	2[e]	2[e]	1[e]	1[e]
Lithuania	5[e]	5[e]	6[e]	10[e]	13[e]	9[e]	4[e]	6[e]	-1[e]
Luxembourg	7[e]	8[e]	7[e]	6[e]	7[e]	5[e]	6[e]	4[e]	4[e]
Hungary	-1	1	3	-2	-2	-1	3	-4	-3
Malta	58[e]	53[e]	43[e]	57[e]	45[e]	46[e]	49[e]	43[e]	36[e]
Netherlands	20	14	21	14	16	17	11	8	5

Source: Eurostat, soil statistics webpage, http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&pcode=t2020_rn310&language=en (accessed 11 January 2018).

Figure 6.5 pH distribution of soils of Latin America and the Caribbean, 2014

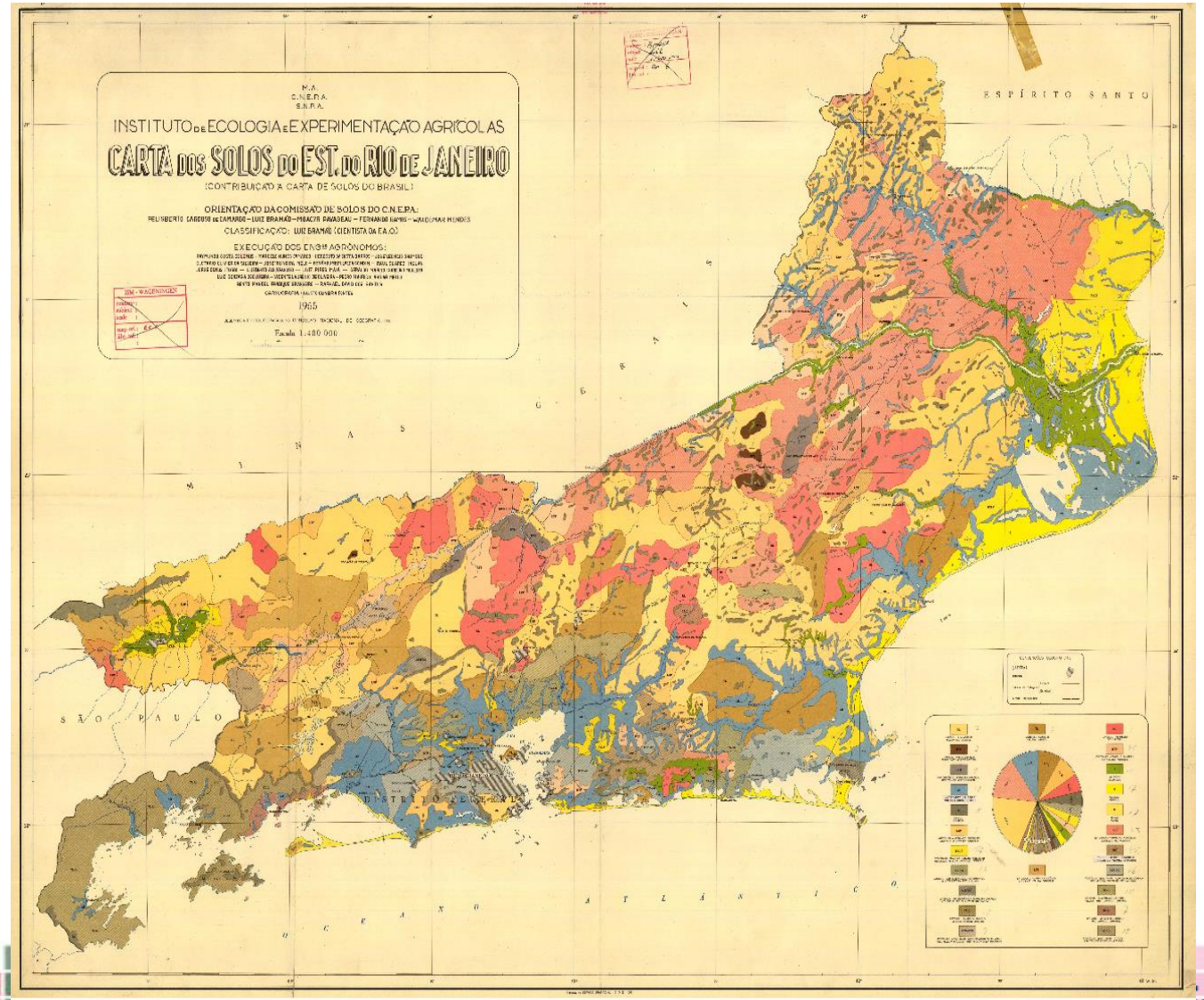


El pH es una designación numérica de la acidez o alcalinidad en el suelo (ver página 11). Un pH de 7 se considera un valor neutro, mientras que los valores inferiores son catalogados como ácidos y los superiores como alcalinos o básicos. Es un parámetro fundamental del suelo, ya que controla muchos procesos químicos, como aquellos relacionados con la disponibilidad de los nutrientes necesarios para los vegetales. El intervalo de pH óptimo para la mayoría de las plantas está entre 6 y 7,5, sin embargo muchas especies han desarrollado adaptaciones para crecer en suelos con valores fuera de este rango. Los suelos ácidos se encuentran fundamentalmente en las zonas con altas precipitaciones, donde los cationes básicos más móviles son lixiviados (lavados) del suelo, aumentando los niveles de los cationes Al^{3+} y H^+. Los suelos alcalinos se caracterizan por la presencia de sales solubles. La aplicación de cal a los suelos ácidos puede aumentar los valores de pH y permitir el cultivo de especies que de otra manera no se podrían cultivar. [SOTERLAC] (JRC)

Source: European Commission (2014) Soil Atlas of Latin America and the Caribbean, https://esdac.jrc.ec.europa.eu/Library/Maps/LatinAmerica_Atlas/Index.html (accessed 11 January 2018)

Shows the pH balance of soils in Latin America and the Caribbean.

Figure 6.6 Soil chart of the state of Rio de Janeiro



Source: Brazil Government (1955) Institute of Ecology, https://esdac.jrc.ec.europa.eu/images/Eudasm/latinamerica/images/maps/download/br13015.jpg (accessed 11 January 2018)
An example of a traditional soil map using soil survey data.

Figure 6.7 Degradation of the soil resource in Mexico by level of degradation

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Source: México (2013) National Forestry Commission.
Shows soil degradation by categories of light, moderate, severe and extreme.

6B. SEEA accounts/tables that use these statistics

The SEEA[52] Asset accounts for soil resources relate only to the top layers of soils. Quantities of soil extracted are not accounted for in these tables.

Table 5.17: Physical asset account for area of soil resources
Accounts for soil resources by soil type only for land used for agriculture and forestry and volumes to be extracted for use as a biological system. It covers opening and closing stocks, additions to stock from changes in land cover, changes in soil quality, and changes in soil environment; and reductions to stock from the same.

Table 5.18: Physical asset account for volume of soil resources
The soil resources are classified by type of soil and by geographical region or land use/land cover type. Changes in volume for excavation are also recorded. The table aims to show changes due to erosion. It covers opening and closing stock, additions to stock from soil formation and deposition, upward reappraisals, reclassifications; and reductions in stock from extractions, soil erosion, catastrophic losses and downward reappraisals.

52. United Nations and FAO (2018) System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA-AFF) white cover version http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Publications/Agrienvironmental/SEEA_AFF_FINAL_Clean_03.pdf (accessed 19 March 2018)

6C. Commonly used indicators that incorporate these statistics

Some indicators that are commonly used for soils:

- Area by soil type (as a proportion of the total surface area).
  Area by soil types (1.1.4.a.1) / Total land area
- Availability of soil nutrients (nitrogen, phosphorous, calcium, magnesium, potassium, carbon)
  For example, Total Organic Carbon (1.1.4.c.7) as a percentage
- Eroded soil surface (as a proportion of the total area).
  Area affected by soil erosion (1.1.4.b.1) / Total land area

6D. SDG indicators that incorporate these statistics

15.3.1 Proportion of land that is degraded over total land area

Indicator of Target 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

The indicator is measured by three sub-indicators, land cover, land productivity and carbon stock[53] The information from the UNCCD Reporting Process under the UNCCD 2018-2030 Strategic Framework will also be used to inform the SDG Indicator 15.3.1. Of these the carbon stock, FDES 1.1.4.c.7, is relevant. The sub-indicator on carbon stock is pertinent to this methodology sheet.

The sub-indicator is measured taking soil organic carbon at a baseline period to assess whether it is degraded or not degraded; and at each monitoring period to assess whether it is positive or improving, negative or declining, or stable or unchanging. Degraded occurs where the sub-indicator is negative, or stable following a negative trend in the preceding time period.

53. SDG Metadata 15.3.1 webpage, https://unstats.un.org/sdgs/metadata/files/Metadata-15-03-01.pdf (accessed 14 January 2018)

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